5.4.3 SEVERE STORM

This section provides a profile and vulnerability assessment for the severe storm hazard.

HAZARD PROFILE

This section provides profile information including description, extent, location, previous occurrences and losses and the probability of future occurrences.

Description

For the purpose of this HMP and as deemed appropriated by the County, the severe storm hazard includes hailstorms, windstorms, lightning, thunderstorms, tornadoes, and tropical cyclones (e.g. hurricanes, tropical storms, and tropical depressions), which are defined below. Since most northeasters, (or Nor'Easters) a type of an extra-tropical cyclone, generally take place during the winter weather months, Nor'Easters have been grouped as a type of severe winter weather storm, further discussed in Section 5.4.2 Severe Winter Storm.

Hailstorm: According to the National Weather Service (NWS), hail is defined as a showery precipitation in the form of irregular pellets or balls of ice more than five millimeters in diameter, falling from a cumulonimbus cloud (NWS, 2005). Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight; they fall as precipitation, in the form of balls or irregularly shaped masses of ice. The size of hailstones is a direct function of the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the Earth's surface. Higher temperature gradients relative to elevation above the surface result in increased suspension time and hailstone size. Hailstorms are a potential damaging outgrowth of severe thunderstorms (Northern Virginia Regional Commission [NVRC], 2006). They cause over $1 billion in crop and property damages each year in the U.S., making hailstorms one of the most costly natural disasters (Federal Alliance for Safe Homes, Inc., 2006).

Windstorm: According to the Federal Emergency Management Agency (FEMA), wind is air moving from high to low pressure. It is rough horizontal movement of air (as opposed to an air current) caused by uneven heating of the Earth's surface. It occurs at all scales, from local breezes generated by heating of land surfaces and lasting tens of minutes to global winds resulting from solar heating of the Earth (FEMA, 1997). A type of windstorm that is experienced often during rapidly moving thunderstorms is a derecho. A derecho is a widespread and long-lived windstorm associated with thunderstorms that are often curved in shape (Johns and Evans, Data Unknown). The two major influences on the atmospheric circulation are the differential heating between the equator and the poles, and the rotation of the planet. Windstorm events are associated with cyclonic storms (for example, hurricanes), thunderstorms and tornadoes (FEMA, 1997).

Lightning: According to the NWS, lightning is a visible electrical discharge produced by a thunderstorm. The discharge may occur within or between clouds or between a rain cloud and the ground (NWS, 2005). The discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm creates a "bolt" when the buildup of charges becomes strong enough. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit (°F). Lightning rapidly heats the sky as it flashes but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder. Annually, on average, 300 people are injured and 89 people are killed due to lightning strikes in the U.S. (NVRC, 2006).

Thunderstorm: According to the NWS, a thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (NWS, 2005). A thunderstorm forms from a combination of moisture, rapidly rising warm air and a force capable of lifting air such as a warm and cold front, a sea breeze, or a mountain. Thunderstorms form from the equator to as far north as Alaska. These storms occur most commonly in the tropics. Many tropical land-based locations experience over 100 thunderstorm days each year (Pidwirny, 2007). Although thunderstorms generally affect a small area when they occur, they are very dangerous because of their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. A thunderstorm produces wind gusts less than 57 miles per hour (mph) and hail, if any, of less than 3/4-inch diameter at the surface. A severe thunderstorm has thunderstorm related surface winds (sustained or gusts) of 57 mph or greater and/or surface hail 3/4-inch or larger (NWS, 2005). Wind or hail damage may be used to infer the occurrence/existence of a severe thunderstorm (Office of the Federal Coordinator for Meteorology, 2001).

Tornado: A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. It is spawned by a thunderstorm (or sometimes as a result of a hurricane) and produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly. Tornado season is generally March through August, although tornadoes can occur at any time of year (FEMA, 2004). Tornadoes tend to strike in the afternoons and evening, with over 80 percent (%) of all tornadoes striking between noon and midnight (New Jersey Office of Emergency Management [NJOEM], 2005). The average forward speed of a tornado is 30 mph, but can vary from nearly stationary to 70 mph (NWS, 1995). The NOAA Storm Prediction Center (SPC) indicates that the total duration of a tornado can last between a few seconds to over one hour; however, a tornado typical lasts less than 10 minutes (Edwards, 2009). High-wind velocity and wind-blown debris, along with lightning or hail, result in the damage caused by tornadoes. Destruction caused by tornadoes depends on the size, intensity, and duration of the storm. Tornadoes cause the greatest damage to structures that are light, such as residential homes and mobile homes, and tend to remain localized during impact (NVRC, 2006).

Tropical Cyclone: Tropical cyclone is a generic term for a cyclonic, low-pressure system over tropical or sub-tropical waters (National Atlas, 2008); containing a warm core of low barometric pressure which typically produces heavy rainfall, powerful winds and storm surge (New York City Office of Emergency Management [NYCOEM], 2007). It feeds on the heat released when moist air rises and the water vapor in it condenses (Dorrego, Date Unknown). Depending on their location and strength, there are various terms by which tropical cyclones are known, such as hurricane, typhoon, tropical storm, cyclonic storm and tropical depression (Pacific Disaster Center, 2006). While tropical cyclones begin as a tropical depression, meaning the storm has sustained winds below 38 mph, it may develop into a tropical storm (with sustained winds of 39 to 73 mph) or a hurricane (with winds of 74 mph and higher).

Tropical Depression: A tropical depression is an organized system of clouds and thunderstorms with a defined surface circulation and maximum sustained winds of less than 38 mph. It has no "eye" (the calm area in the center of the storm) and does not typically have the organization or the spiral shape of more powerful storms (Emanuel, Date Unknown; Miami Museum of Science, 2000).

Tropical Storm: A tropical storm is an organized system of strong thunderstorms with a defined surface circulation and maximum sustained winds between 39 and 73 mph (FEMA, 2007). Once a storm has reached tropical storm status, it is assigned a name. During this time, the storm itself becomes more organized and begins to become more circular in shape, resembling a hurricane. The rotation of a tropical storm is more recognizable than a tropical depression. Tropical storms can cause a lot of problems, even without becoming a hurricane; however, most of the problems stem from heavy rainfall (University of Illinois, Date Unknown).

Hurricane: A hurricane is an intense tropical cyclone with wind speeds reaching a constant speed of 74 mph or more (FEMA, 2004). It is a category of tropical cyclone characterized by thunderstorms and defined surface wind circulation. They are caused by the atmospheric instability created by the collision of warm air with cooler air. They form in the warm waters of tropical and sub-tropical oceans, seas, or Gulf of Mexico (NWS, 2000). Most hurricanes evolve from tropical disturbances. A tropical disturbance is a discrete system of organized convection (showers or thunderstorms), that originate in the tropics or subtropics, does not migrate along a frontal boundary, and maintains its identity for 24 hours or more (NWS, 2004). Hurricanes begin when areas of low atmospheric pressure move off the western coast of Africa and into the Atlantic, where they grow and intensify in the moisture-laden air above the warm tropical ocean. Air moves toward these atmospheric lows from all directions and circulates clock-wise under the influence of the Coriolis effect, thereby initiating rotation in the converging wind fields. When these hot, moist air masses meet, they rise up into the atmosphere above the low pressure area, potentially establishing a self-reinforcing feedback system that produces weather systems known to meteorologists as tropical disturbances, tropical depressions, tropical storms, and hurricanes (Frankenberg, 1999).

Almost all tropical storms and hurricanes in the Atlantic basin, which includes the Gulf of Mexico and Caribbean Sea, form between June 1st and November 30th. This time frame is known as hurricane season. August and September are peak months for hurricane development. The threats caused by an approaching hurricane can be divided into three main categories: storm surge, wind damage and rainfall/flooding:

- *Storm Surge* is simply water that is pushed toward the shore by the force of the winds swirling around the storm. This advancing surge combines with the normal tides to create the hurricane storm tide, which can increase the mean water level 15 feet or more. Storm surge is responsible for nearly 90-percent of all hurricane-related deaths and injuries.
- *Wind Damage* is the force of wind that can quickly decimate the tree population, down power lines and utility poles, knock over signs, and damage/destroy homes and buildings. Flying debris can also cause damage to both structures and the general population. When hurricanes first make landfall, it is common for tornadoes to form which can cause severe localized wind damage.
- *Rainfall / Flooding* the torrential rains that normally accompany a hurricane can cause serious flooding. Whereas the storm surge and high winds are concentrated around the “eye”, the rain may extend for hundreds of miles and may last for several days, affecting areas well after the hurricane has diminished (Mandia, 2007).

Extent

The extent (that is, magnitude or severity) of a severe storm is largely dependent upon sustained wind speed. Straight-line winds, winds that come out of a thunderstorm, in extreme cases, can cause wind gusts exceeding 100 mph. These winds are most responsible for hailstorm and thunderstorm wind damage. One type of straight-line wind, the downburst, can cause damage equivalent to a strong tornado (NVRC, 2006).

Tornado

The magnitude or severity of a tornado was originally categorized using the Fujita Scale (F-Scale) or Pearson Fujita Scale introduced in 1971, based on a relationship between the Beaufort Wind Scales (B-Scales) (measure of wind intensity) and the Mach number scale (measure of relative speed). It is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure (Tornado Project, Date Unknown). The F-Scale categorizes each tornado by intensity and area. The scale is divided into six categories, F0 (Gale) to F5 (Incredible) (SPC, 2007). Table 5.4.3-1 explains each of the six F-Scale categories.

Table 5.4.3-1. Fujita Damage Scale

Scale	Wind Estimate (MPH)	Typical Damage
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261-318	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; incredible phenomena will occur.

Source: SPC, Date Unknown

Although the F-Scale has been in use for over 30 years, there are limitations of the scale. The primary limitations are a lack of damage indicators, no account of construction quality and variability, and no definitive correlation between damage and wind speed. These limitations have led to the inconsistent rating of tornadoes and, in some cases, an overestimate of tornado wind speeds. The limitations listed above led to the development of the Enhanced Fujita Scale (EF Scale). The Texas Tech University Wind Science and Engineering (WISE) Center, along with a forum of nationally renowned meteorologists and wind engineers from across the country, developed the EF Scale (NWS, 2007).

The EF Scale became operational on February 1, 2007. It is used to assign tornadoes a 'rating' based on estimated wind speeds and related damage. When tornado-related damage is surveyed, it is compared to a list of Damage Indicators (DIs) and Degrees of Damage (DOD), which help better estimate the range of wind speeds produced by the tornado. From that, a rating is assigned, similar to that of the F-Scale, with six categories from EF0 to EF5, representing increasing degrees of damage. The EF Scale was revised from the original F-Scale to reflect better examinations of tornado damage surveys. This new scale has to do with how most structures are designed (NWS, 2007). Table 5.4.3-2 displays the EF Scale and each of its six categories.

Table 5.4.3-2. Enhanced Fujita Damage Scale

F-Scale Number	Intensity Phrase	Wind Speed (mph)	Type of Damage Done
EF0	Light tornado	65–85	Light damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	Moderate tornado	86-110	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	Significant tornado	111-135	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	Severe tornado	136-165	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	Devastating tornado	166-200	Devastating damage. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	Incredible tornado	>200	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (109 yd); high-rise buildings have significant structural deformation; incredible phenomena will occur.

Source: SPC, 2007

In the Fujita Scale, there was a lack of clearly defined and easily identifiable damage indicators. The EF Scale takes into account more variables than the original F-Scale did when assigning a wind speed rating to a tornado. The EF Scale incorporates 28 damage indicators (DIs), such as building type, structures, and trees. For each damage indicator, there are eight degrees of damage (DOD), ranging from the beginning of visible damage to complete destruction of the damage indicator. Table 5.4.3-3 lists the 28 DIs. Each one of these indicators has a description of the typical construction for that category of indicator. Each DOD in every category is given an expected estimate of wind speed, a lower bound of wind speed, and an upper bound of wind speed.

Table 5.4.3-3. Enhanced F-Scale Damage Indicators

Number	Damage Indicator	Abbreviation	Number	Damage Indicator	Abbreviation
1	Small barns, farm outbuildings	SBO	15	School - 1-story elementary (interior or exterior halls)	ES
2	One- or two-family residences	FR12	16	School - jr. or sr. high school	JHSH
3	Single-wide mobile home (MHSW)	MHSW	17	Low-rise (1-4 story) bldg.	LRB

Number	Damage Indicator	Abbreviation	Number	Damage Indicator	Abbreviation
4	Double-wide mobile home	MHDW	18	Mid-rise (5-20 story) bldg.	MRB
5	Apt, condo, townhouse (3 stories or less)	ACT	19	High-rise (over 20 stories)	HRB
6	Motel	M	20	Institutional bldg. (hospital, govt. or university)	IB
7	Masonry apt. or motel	MAM	21	Metal building system	MBS
8	Small retail bldg. (fast food)	SRB	22	Service station canopy	SSC
9	Small professional (doctor office, branch bank)	SPB	23	Warehouse (tilt-up walls or heavy timber)	WHB
10	Strip mall	SM	24	Transmission line tower	TLT
11	Large shopping mall	LSM	25	Free-standing tower	FST
12	Large, isolated ("big box") retail bldg.	LIRB	26	Free standing pole (light, flag, luminary)	FSP
13	Automobile showroom	ASR	27	Tree - hardwood	TH
14	Automotive service building	ASB	28	Tree - softwood	TS

Source: SPC, Date Unknown

Since the EF Scale recently went into effect in February 2007, previous occurrences and losses associated with historic tornado events, described in the next section (Previous Occurrences and Losses) of this hazard profile are based on the former Fujita Scale.

Hurricanes

The extent of a hurricane is categorized by the Saffir-Simpson Hurricane Scale. This scale categorizes or rates hurricanes from 1 (Minimal) to 5 (Catastrophic) based on their intensity. This is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the coastline, in the landfall region (National Hurricane Center [NHC], 2007). Table 5.4.3-4 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes land fall.

Table 5.4.3-4 The Saffir-Simpson Scale

Category	Wind Speed (mph)	Storm Surge (above normal sea level)	Expected Damage
1	74-95	4 – 5 feet	Minimal: Damage is done primarily to shrubbery and trees, unanchored mobile homes are damaged, some signs are damaged, and no real damage is done to structures.

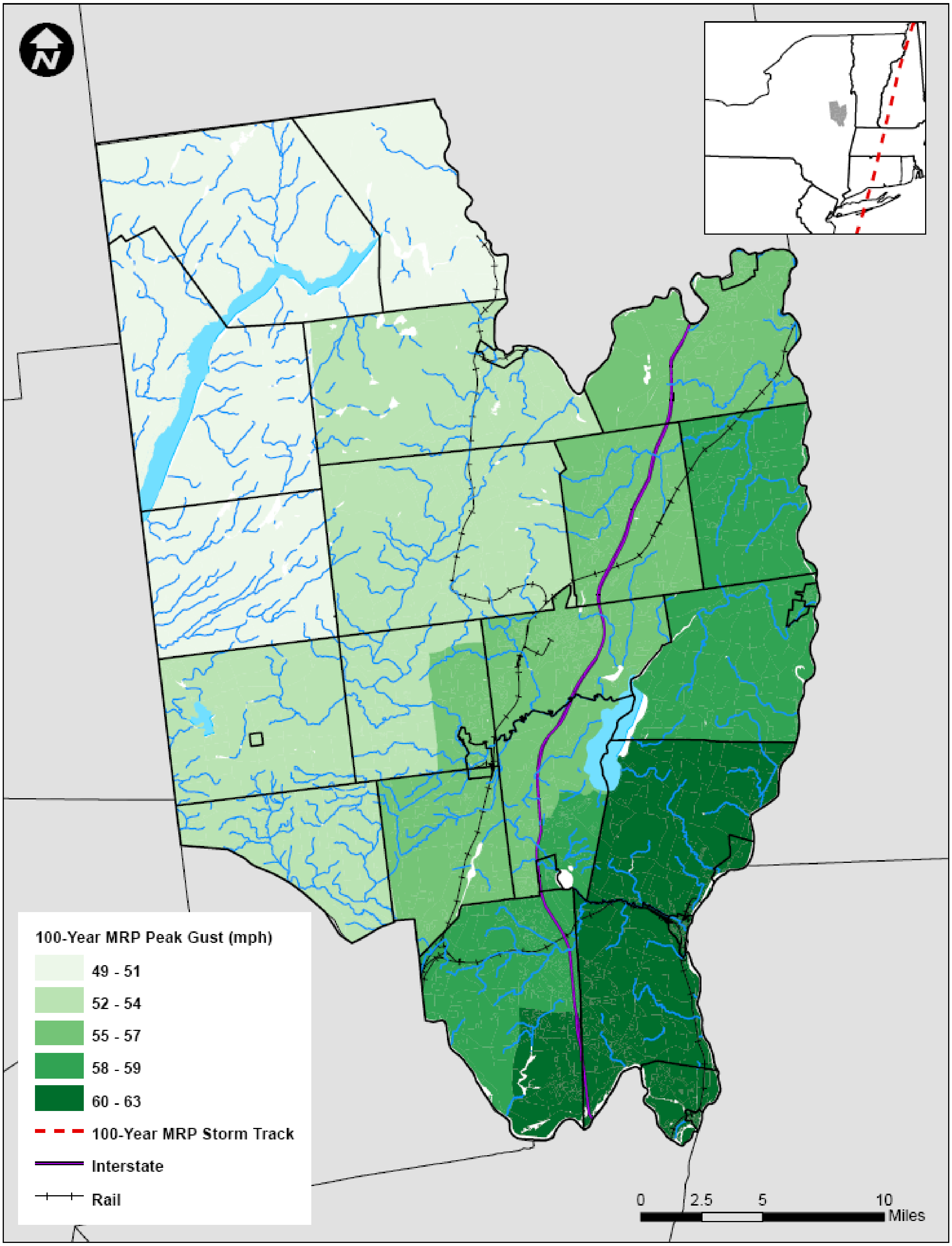
Category	Wind Speed (mph)	Storm Surge (above normal sea level)	Expected Damage
2	96-110	6 – 8 feet	Moderate: Some trees are toppled, some roof coverings are damaged, and major damage is done to mobile homes.
3	111-130	9 – 12 feet	Extensive: Large trees are toppled, some structural damage is done to roofs, mobile homes are destroyed, and structural damage is done to small homes and utility buildings.
4	131-155	13 – 18 feet	Extreme: Extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; and some curtain walls fail.
5	> 155	> 18 feet	Catastrophic: Roof damage is considerable and widespread, window and door damage is severe, there are extensive glass failures, and entire buildings could fail.
Additional Classifications			
Tropical Storm	39-73	0 - 3 feet	NA
Tropical Depression	< 38	0	NA

Source: FEMA, 2007
mph = Miles per hour
> = Greater than
NA = Not applicable or not available

In evaluating the potential for hazard events of a given magnitude, a mean return period (MRP) is often used. The MRP provides an estimate of the magnitude of an event that may occur within any given year based on past recorded events. MRP is the average period of time, in years, between occurrences of a particular hazard event (equal to the inverse of the annual frequency of exceedance) (Dinicola, 2005).

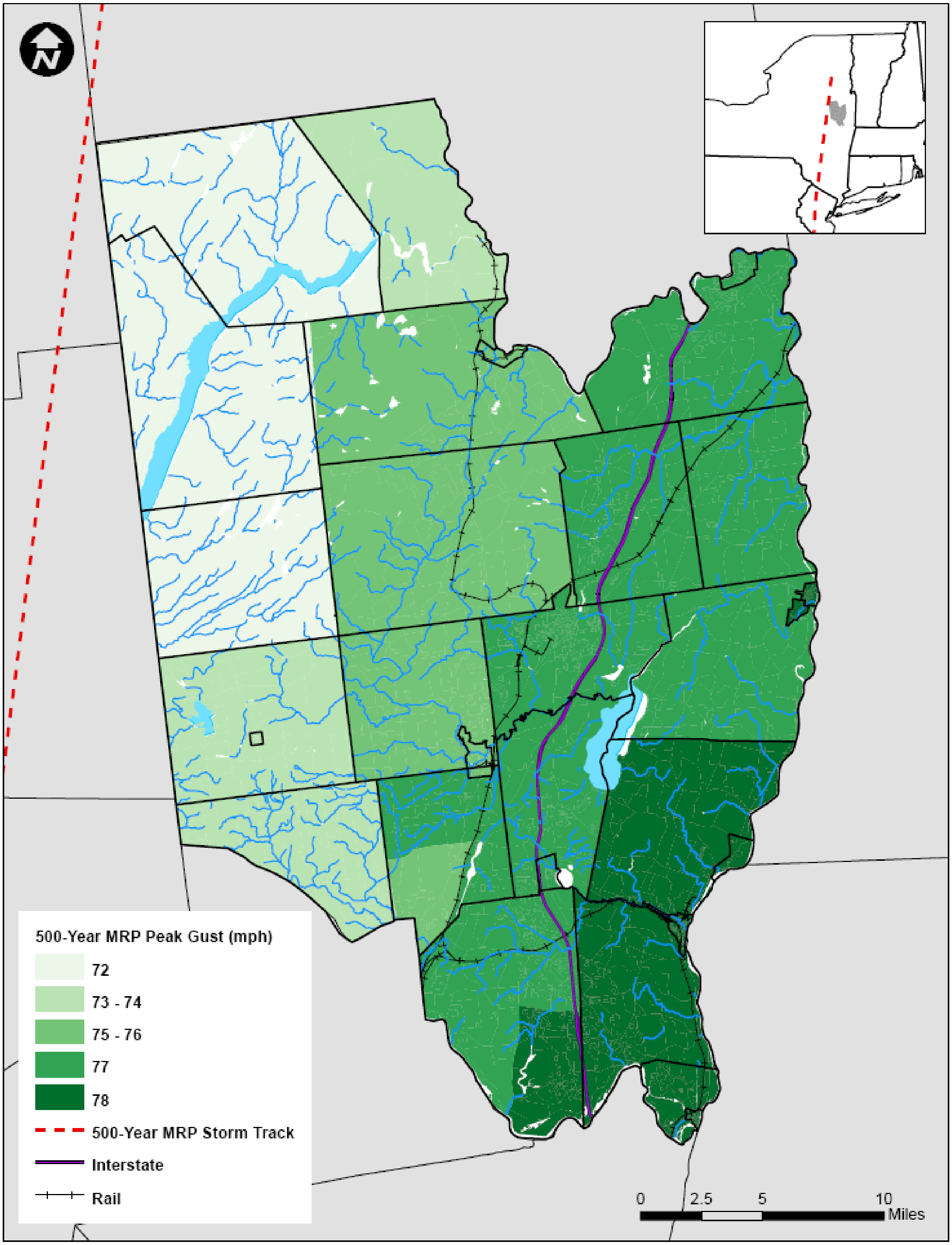
Figures 5.4.3-1 and 5.4.3-2 show the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP HAZUS-MH model runs. The estimated hurricane track for the 100- and 500-year event is also shown. The maximum 3-second gust wind speeds for the County range from 49 to 63 mph for the 100-year MRP event; wind speeds characteristic of a tropical storm. The maximum 3-second gust wind speeds for the County range from 72 to 78 mph for the 500-year MRP event; wind speeds characteristic of a Category 1 hurricane. The associated impacts and losses from these 100-year and 500-year MRP hurricane event model runs are reported in the Vulnerability Assessment later in this section.

Figure 5.4.3-1 Peak Wind Speeds for the 100-Year MRP Wind Event in Saratoga County



Source: HAZUS-MH MR3, 2007

Figure 5.4.3-2. Peak Wind Speeds for the 500-Year MRP Wind Event in Saratoga County



Source: HAZUS-MH MR3, 2007

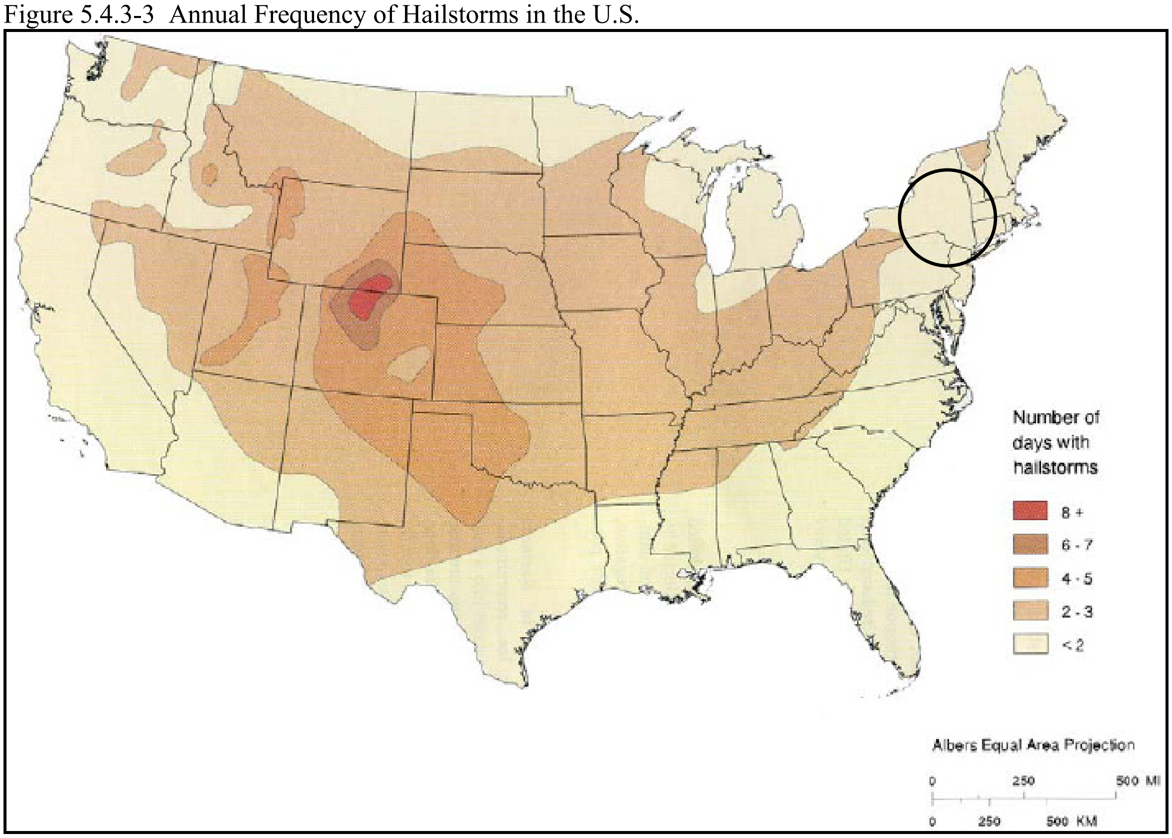
Location

Severe storms are a common natural hazard in New York State because the State exhibits a unique blend of weather (geographically and meteorological) features that influence the potential for severe storms and associated flooding. Factors include temperature, which is affected by latitude, elevation, proximity to water bodies and source of air masses; and precipitation which includes snowfall and rainfall. Precipitation intensities and effects are influenced by temperature, proximity to water bodies, and general frequency of storm systems. The Cornell Climate Report also indicates that the geographic position of the State (Northeast U.S.) makes it vulnerable to frequent storm and precipitation events. This is because nearly all storms and frontal systems moving eastward across the continent pass through, or in close proximity to New York State. Additionally, the potential for prolonged thunderstorms or coastal storms and periods of heavy precipitation is increased throughout the state because of the available moisture that originates from the Atlantic Ocean (NYSDPC, 2008).

Hailstorms

Hailstorms are more frequent in the southern and central plain states, where the climate produces violent thunderstorms. However, hailstorms have been observed in almost every location where thunderstorms occur (Federal Alliance for Safe Homes, Inc, 2006). Figure 5.4.3-3 illustrates that Saratoga County and most of New York State experience less than two hailstorms per year.

Figure 5.4.3-3 Annual Frequency of Hailstorms in the U.S.



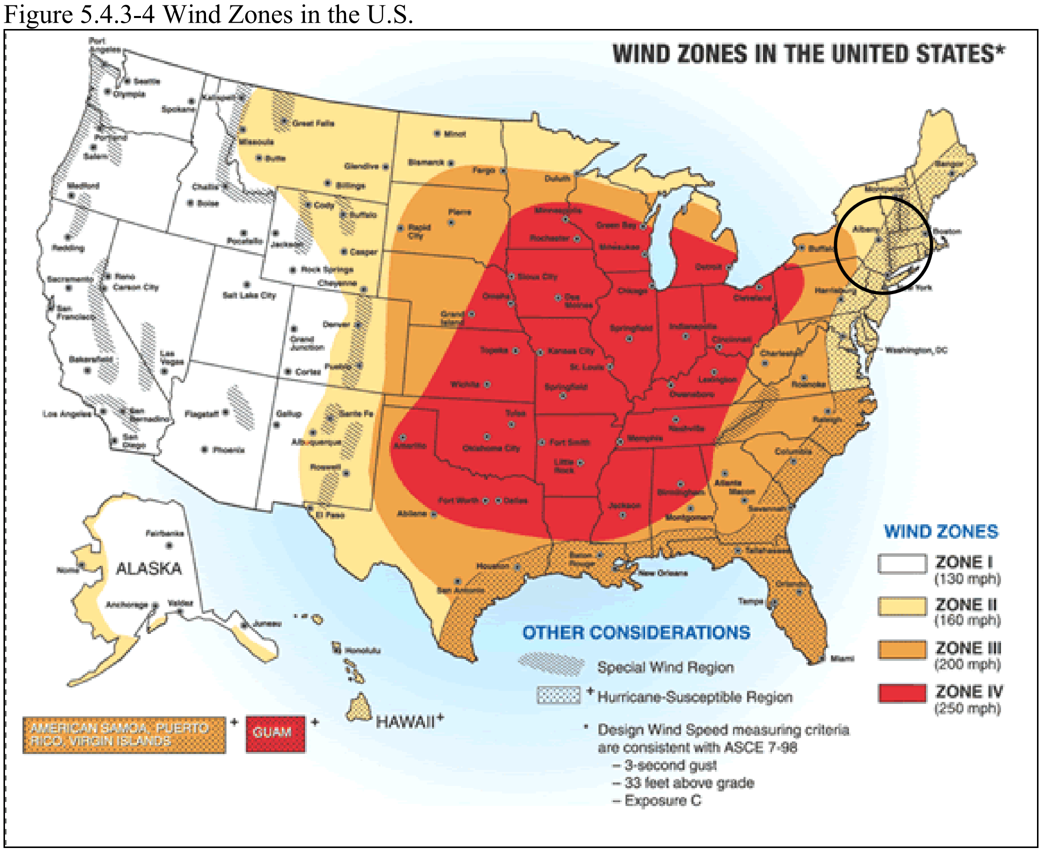
Source: NVRC, 2006
Note: The black circle indicates the approximate location of Saratoga County. Saratoga County experiences less than two hailstorms a year.

Windstorms

Figure 5.4.3-4 indicates how the frequency and strength of windstorms impacts the U.S. and the general location of the most wind activity. This is based on 40 years of tornado history and 100 years of hurricane history, collected by FEMA. States located in Wind Zone IV have experienced the greatest number of tornadoes and the strongest tornadoes (NVRC, 2006). Saratoga County is located in Wind Zone II with speeds up to 160 miles per hour. The County is also located within the Hurricane Susceptibility Region, which extends along the northeastern coastline of the U.S. (FEMA, 2006).

The New York State Hazard Mitigation Plan (NYS HMP) identifies counties most vulnerable to wind, as determined by a rating score. Counties accumulate points based on the value of each vulnerability indicator, the higher then indication for wind exposure the more points assigned, resulting in a final rating score. Saratoga County was given a rating score of 11, a medium vulnerability to wind exposure (NYSDPC, 2008).

Figure 5.4.3-4 Wind Zones in the U.S.

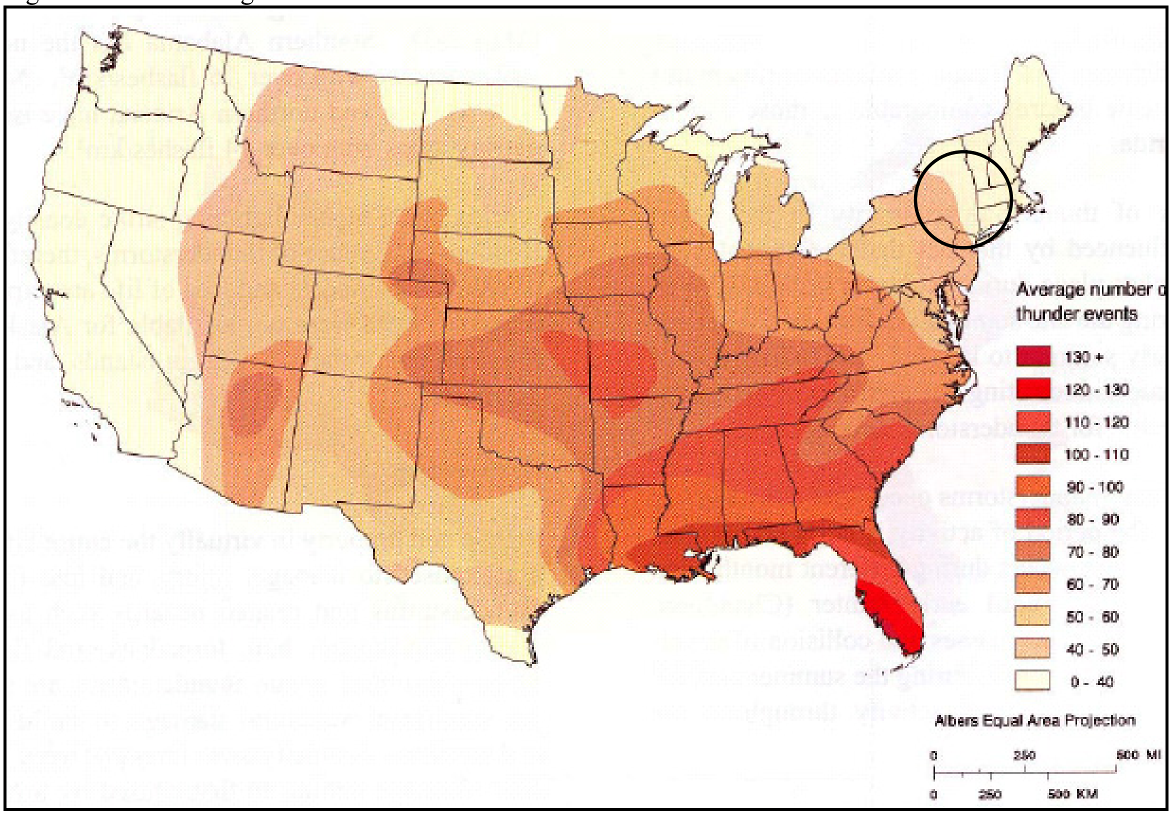


Source: FEMA, 2006
Note: The black circle indicates the approximate location of Saratoga County.

Thunderstorms

Thunderstorms affect relatively small localized areas, rather then large regions much like winter storms, and hurricane events (NWS, 2005). Thunderstorms can strike in all regions of the U.S.; however, they are most common in the central and southern states. The atmospheric conditions in these regions of the country are most ideal for generating these powerful storms (NVRC, 2006). More than 100,000 thunderstorms occur each year in the U.S., however, only about 10-percent are classified as "severe" (NOAA, 2005). The NWS collected data for thunder days, number and duration of thunder events, and lightening strike density for the 30-year period from 1948 to 1977. A map was produced by the NWS, illustrating thunderstorm hazard severity in the U.S., based on the annual average number of thunder events between 1948 and 1977 (Figure 5.4.3-5) (NVRC, 2006). This figure indicates that Saratoga County experienced between 0 and 40 annual thunder events during this time period.

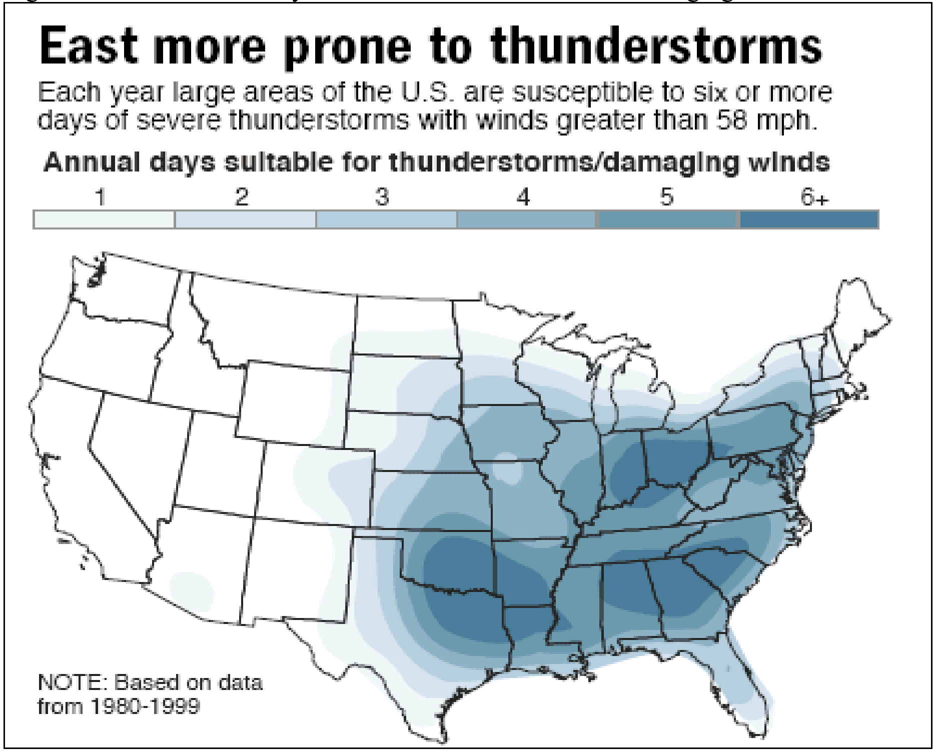
Figure 5.4.3-5. Average Number of Thunderstorms between 1948 and 1977 in the U.S.



Source: NVRC, 2006
Note: The black circle indicates the approximate location of Saratoga County.

NASA scientists suggest that the U.S. will face more severe thunderstorms in the future, with deadly lightning, damaging hail and the potential for tornadoes in the event of climate change (Borenstein, 2007). A recent study conducted by NASA predicts that smaller storm events like thunderstorms will be more dangerous due to climate change (Figure 5.4.3-6). As prepared by the NWS, Figure 5.4.3-6 identifies those areas, particularly within the eastern U.S. that are more prone to thunderstorms, which includes New York State.

Figure 5.4.3-6. Annual Days Suitable for Thunderstorms/Damaging Winds

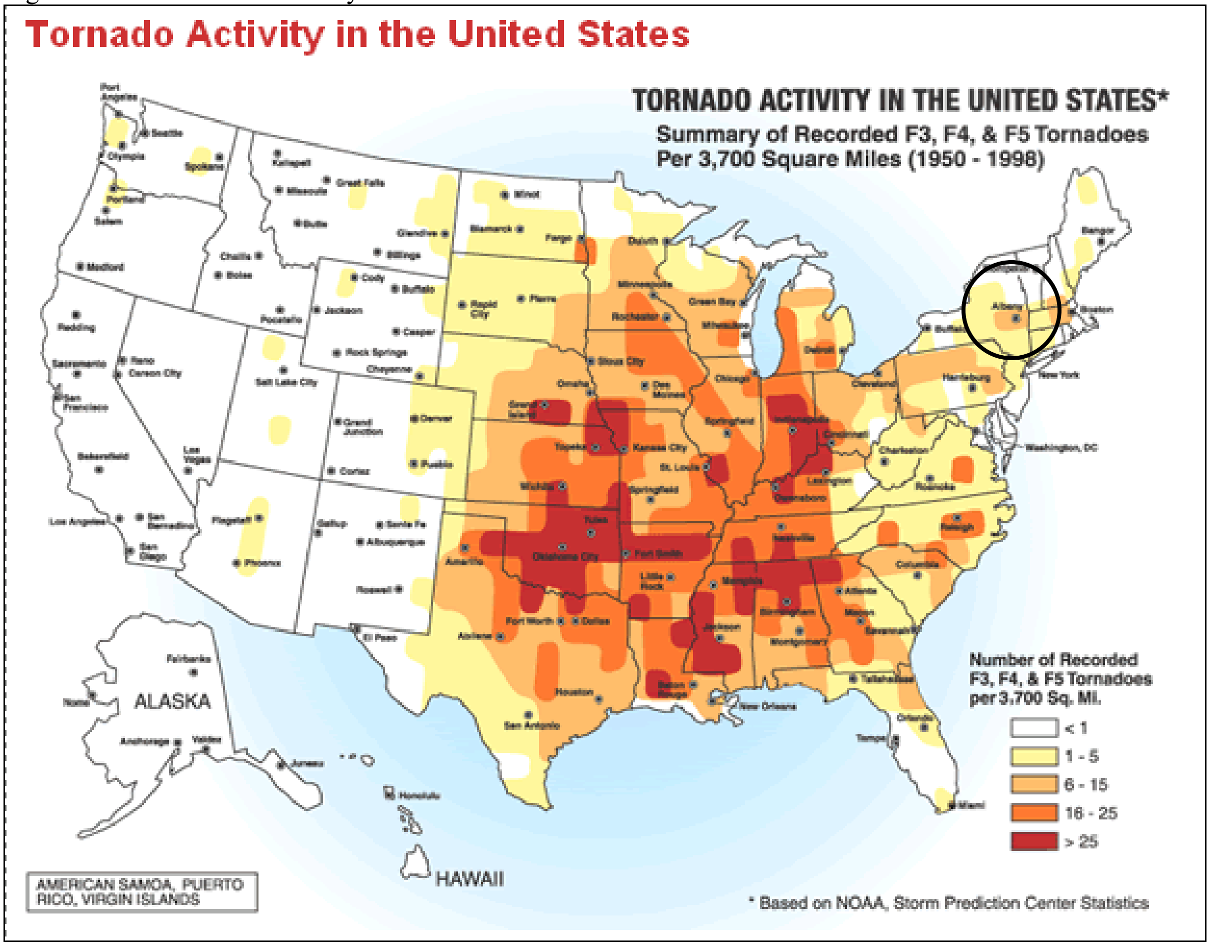


Source: MSNBC.com, 2007

Tornado

According to the NWS, an average of 800 tornadoes affects the U.S. each year. These tornadoes typically result in approximately 80 deaths and over 1,500 injuries annually. The highest concentration of tornadoes in the U.S. has been in Oklahoma, Texas, Kansas, and Florida, as well as the Great Plains region of the central U.S. Tornadoes have also been observed in the central and eastern portion of the U.S (NVRC, 2006). Figure 5.4.3-7 shows tornado activity in the U.S., between 1950 and 1998, based on the number of recorded tornadoes per 3,700 square miles.

Figure 5.4.3-7. Tornado Activity in the U.S.

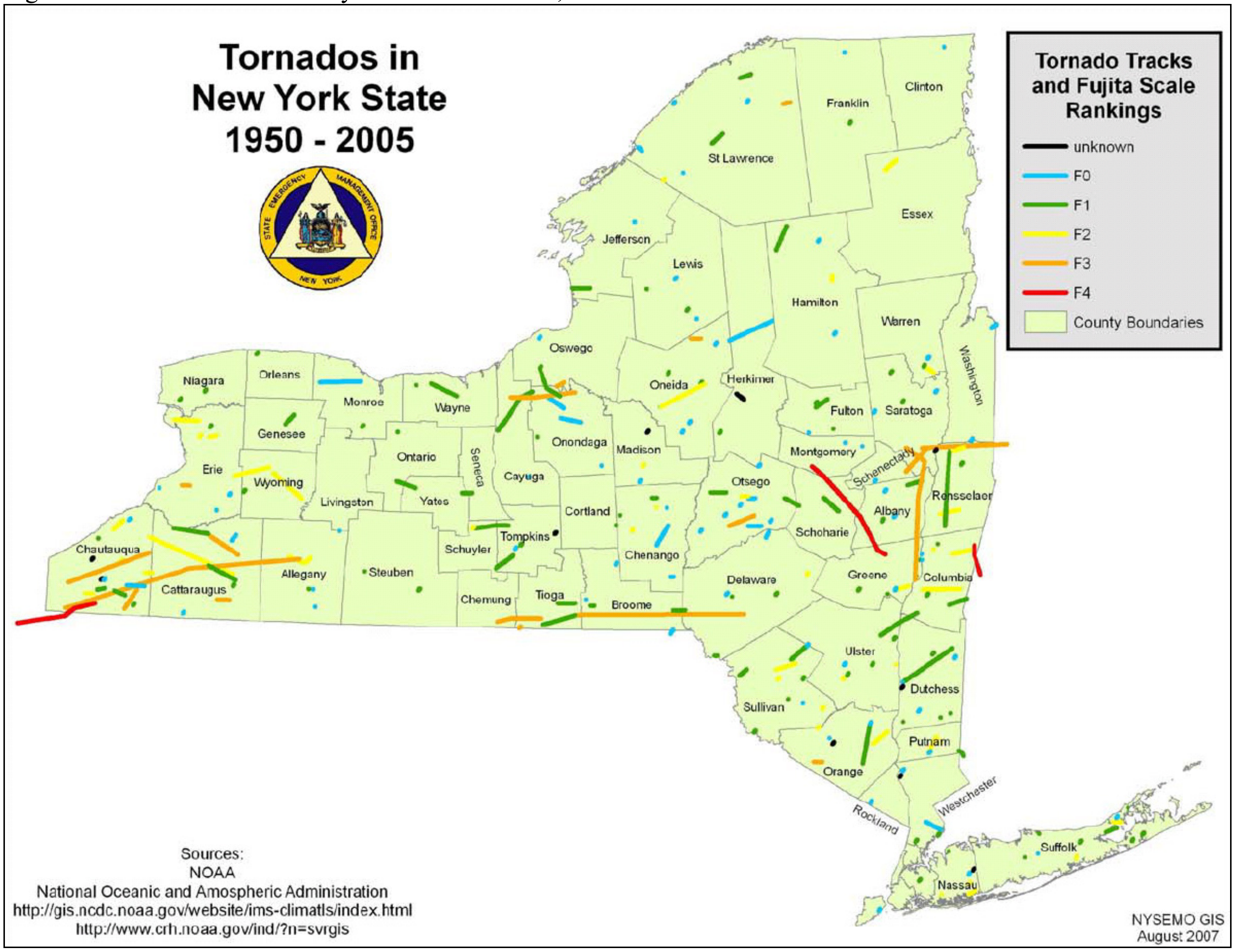


Source: FEMA, 2006

Note: The black circle indicates the approximate location of Saratoga County. Saratoga County experiences between 1 and 15 tornadoes per 3,700 square miles.

New York State ranks 30th in the U.S. for frequency of tornadoes. When compared to other states on the frequency of tornadoes per square mile, New York ranks 35th (The Disaster Center, 2007). New York State has a definite vulnerability to tornadoes and can occur, based on historical occurrences, in any part of the State. According to Figure 5.4.3-8, New York State experiences between 0 and 15 tornadoes per 3,700 square miles and since 1950. The State has experienced 359 tornadoes, ranging from F0 to F4 on the Fujita-Pearson Tornado Intensity Scale. Every county in New York State has experienced a tornado between 1950 and 2007 (NYSDPC, 2008) (Figure 5.4.3-8).

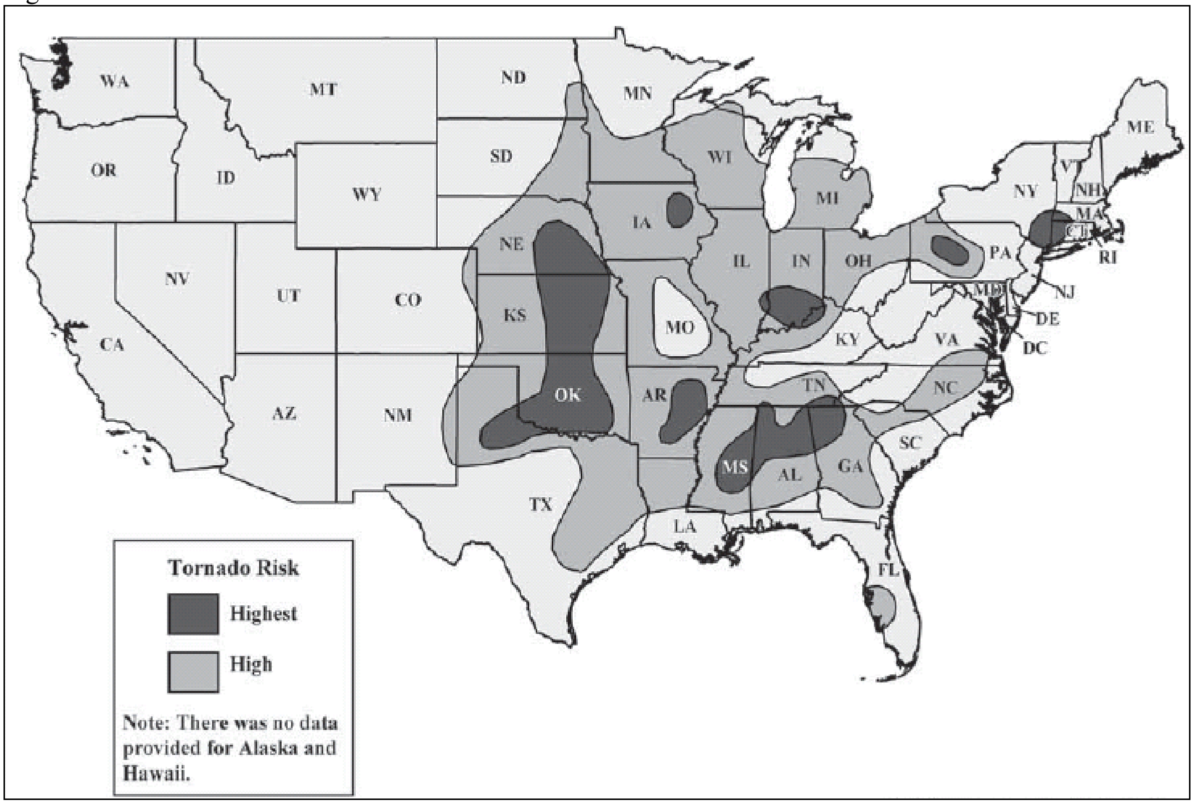
Figure 5.4.3-8. Tornado Activity in New York State, 1950-2005



Source: NYSDPC, 2008

Figure 5.4.3-9 indicates that a majority of the State, with the exception of the southeastern section (Mid-Hudson Region), has an overall low risk of tornado activity, which includes portions of Saratoga County. Details regarding historical tornado events are discussed in the next section (Previous Occurrences and Losses) of this profile.

Figure 5.4.3-9. Tornado Risk in the U.S.

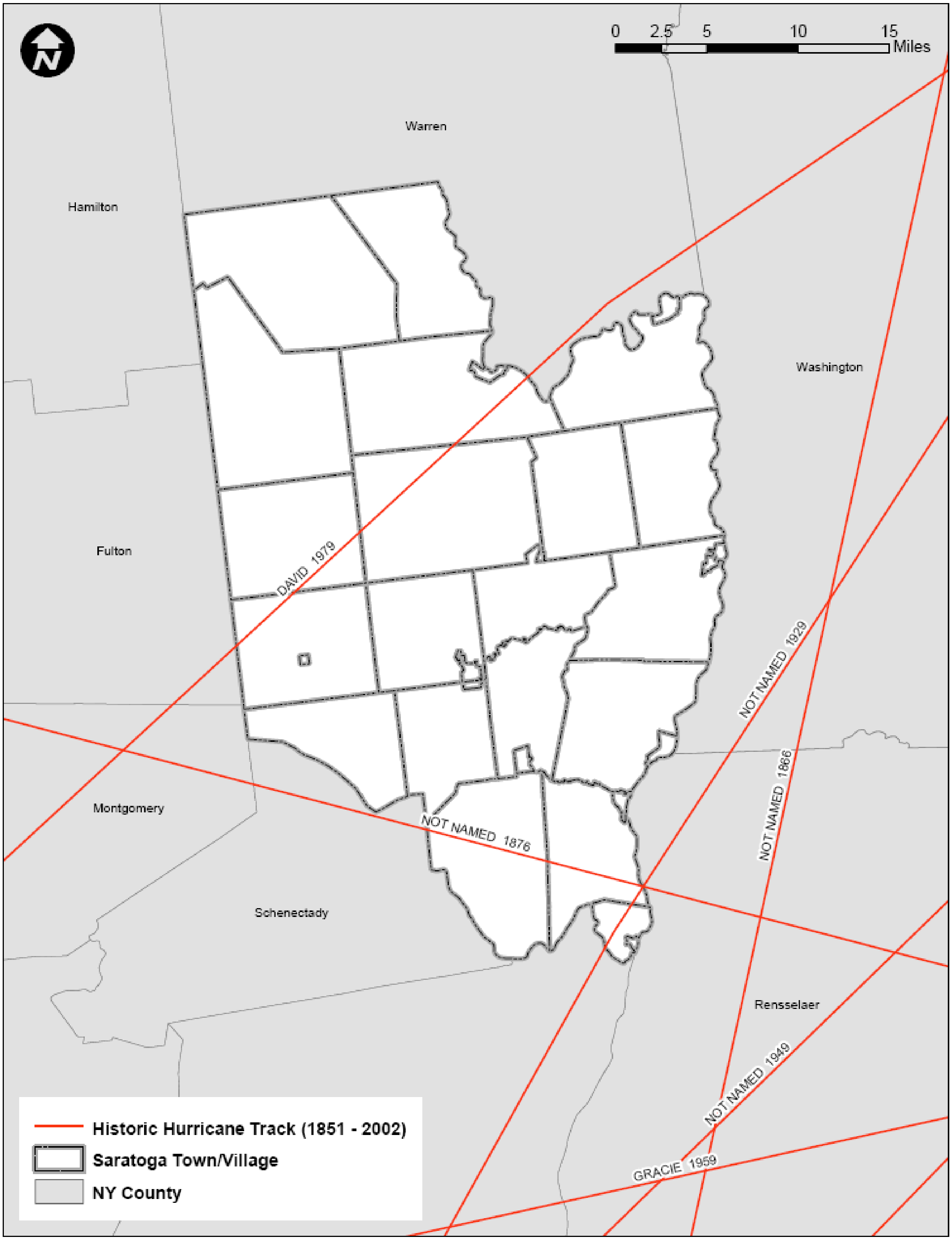


Source: NYSDPC, 2008
Note: Saratoga County is shown has having a high risk and highest risk of tornado occurrences.

Hurricanes / Tropical Storms

Due to Saratoga County's inland location, hurricanes do not often make direct landfall on the mitigation study area. However, the County has more frequently been known to experience tropical storms and their indirect landward effects, including high winds, heavy rains, and major flooding associated with hurricane and/or tropical storm events. Hurricanes and tropical storms can impact New York State from June to November, the official eastern U.S. hurricane season. However, late July to early October is the period hurricanes and tropical storms are most likely to impact New York State, due to the coolness of the North Atlantic Ocean waters (NYSDPC, 2008). Figure 5.4.3-10 illustrates the historic hurricane tracks near Saratoga County from 1851 to 2002.

Figure 5.4.3-10. Historic North Atlantic Tropical Cyclone Tracks, 1851-2002

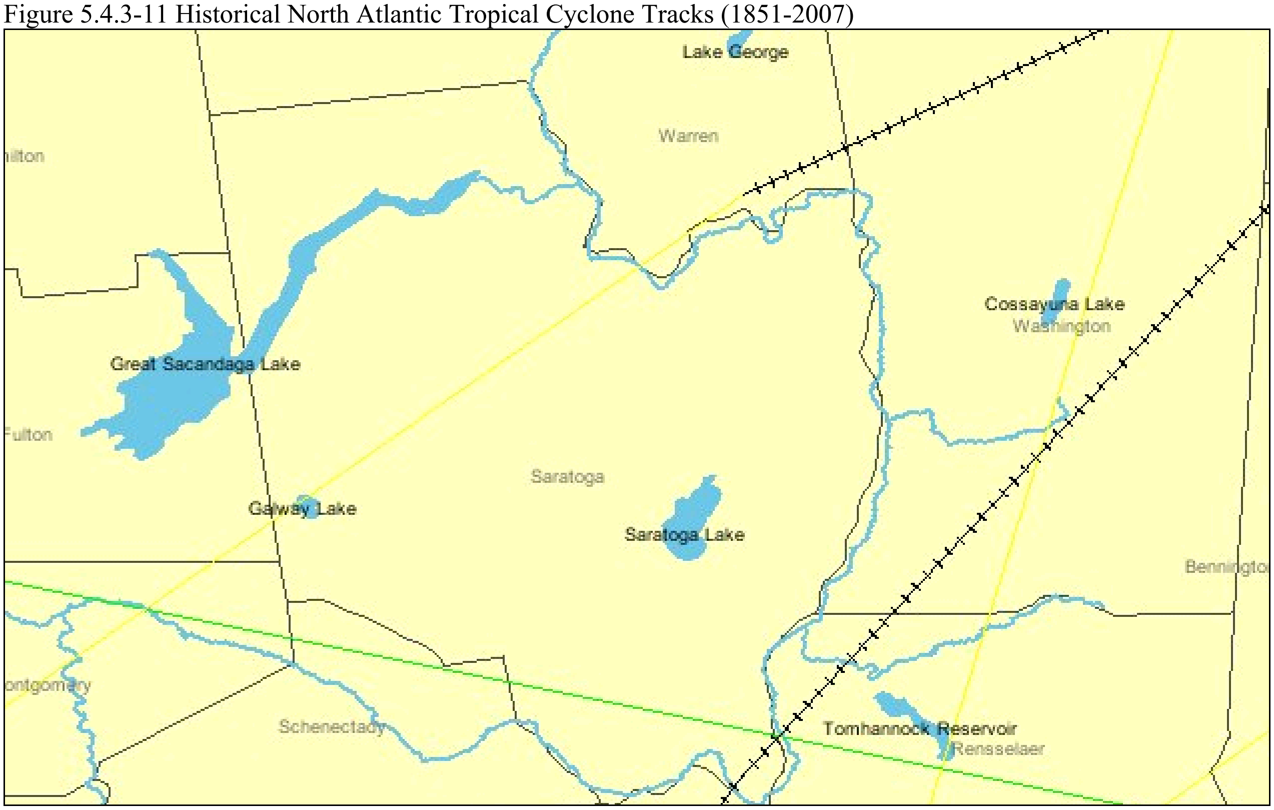


Source: NOAA, 2003

From 1903 to 1989, 24 hurricanes and numerous tropical storms have crossed over New York State. The vast majority of these storms have been over the eastern part of the State, specifically in the southeastern corner. This area includes the New York City metropolitan area and the mid and lower Hudson Valley areas. These areas comprise approximately 61-percent of New York State's population (NYSDPC, 2008).

The Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from 1851 to 2006. Figure 5.4.3-11 displays tropical cyclone tracks for Saratoga County; however, the associated names for some of these events are unknown. Between 1851 and 2007, Saratoga County has experienced 30 tropical cyclone events. These events occurred within 65 nautical miles of the County (NHC, 2006).

Figure 5.4.3-11 Historical North Atlantic Tropical Cyclone Tracks (1851-2007)



Source: NHC, 2006

Note: —— = Tropical Storm David, 1979

—— = Unnamed Tropical Depression, 1876

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with severe storms throughout New York State and Saratoga County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

Between 1954 and 2007, FEMA declared that New York experienced 39 severe storm-related disasters classified as one or a combination of the following disaster types: severe storms, hurricane (Ivan-2004, Floyd-1999, Bob-1991, Gloria-1985, Belle-1976, Agnes-1972), coastal storms, flooding, high tides and heavy rain (FEMA, 2007). Of those events, multiple sources, including FEMA, indicated that Saratoga County was declared a disaster area as a result of three severe storm events. FEMA couples some disasters as severe storms and flooding events; therefore, those severe storm disasters that are also listed as flooding events have been discussed in Section 5.4.1 (Flood) as well. Table 5.4.3-5 summarizes the FEMA Presidential Disaster (DR) or Emergency Declarations (EM) for severe storm events in Saratoga County.

Table 5.4.3-5 Presidential Disaster Declarations for Severe Storm Events in Saratoga County

Type of Event*	Date**	Declaration Number	Cost of Losses (approximate)
Severe Storms and Flooding	January 1996	DR-1095	New York State had over $160 M in total eligible damages. New York State received $16.7 M in individual assistance and $103.7 M in public assistance. NOAA-NCDC indicates that Saratoga County experienced approximately $385 K in property damages related to high winds; however, SHELDUS indicates that Saratoga County experienced approximately $30 K in property damages related to high winds. USGS indicated that Saratoga County received approximately $328 K in individual aid and $1.3 M in public assistance.
Severe Thunderstorms and Tornadoes	May 1998	DR-1222	A major severe weather outbreak struck New York State, bringing severe TSTMs and tornadoes. New York State experienced approximately $6.9 M in eligible damages. Most significant tornado was in Saratoga County. Governor Pataki declared a state of emergency in Saratoga and Rensselaer Counties. NOAA-NCDC and SHELDUS indicate that Saratoga County experienced approximately $60 M in property damages and 68 people were injured.
Severe Storms and Flooding	May-June 2004	DR-1534	New York State experienced approximately $14 M in damages (NYSDPC). More than $6.3 M in public assistance was approved for New York State. In Greenfield Center, 2.6 inches of rain fell in 20 minutes. NOAA-NCDC and SHELDUS indicate that Saratoga County experienced approximately $86,000 in property damages due to hail, lightning, and wind.

Source(s): FEMA, 2008; NYSDPC, 2008; Hazards & Vulnerability Research Institute (SHELDUS), 2008; NCDC, 2008; NYSEMO, 2006

Note (1): Dollars rounded to nearest thousand. Recorded losses indicate the dollar value of covered losses paid, as available through the public records reviewed. Some of these events overlap with events shown under the Flood and Severe Winter Storm hazard profiles of this Plan.

* The 'Type of Event' is the disaster classification that was assigned to the event by FEMA.

** Represents the date of the event

DR = Presidential Disaster
K = Thousand
M = Million
NYSDPC = New York State Disaster Preparedness Commission
NOAA =National Oceanic and Atmospheric Administration
NCDC = National Climatic Data Center
SHELDUS = Spatial Hazard Events and Losses Database for the U.S.
TSTM = Thunderstorms
USGS = United States Geological Survey

Based on all sources researched, many notable severe storm events have impacted Saratoga County. All other severe storm events are identified in Table 5.4.3-6 below; however, severe storm documentation for New York is extensive and, therefore, not all sources may have been identified or researched. Hence, Table 5.4.3-6 may not include all events that have occurred throughout the region.

Table 5.4.3-6. Severe Storm Events between 1882 and 2008

Event Name / Date	Location	Losses / Impacts	Source(s)
Severe Storm June 18, 1882	Countywide	A severe storm hit the County, causing considerable damage. Some of the embankments of the Mount McGregor Railroad were washed out. In the northern sections of the County, heavy hail, along with rain, caused damage and many bridges were washed out.	New York Times
TSTM July 17, 1883	Countywide	A TSTM hit Saratoga County. Lightning struck several places and a woman was injured. Considerable damage was reported.	New York Times
Heavy Rain July 30, 1887	Countywide	A heavy rainstorm, along with lightning, hit the area. Lightning struck several homes.	New York Times
Heavy Rain June 9, 1904	Countywide	Over the past 24-hours, rain fall totals exceeded six inches in many locations. Lightning struck several places. This was the worst storm experienced in years.	New York Times
Severe Storm September 4, 1904	Countywide	A severe storm, bringing rain, hail, wind, thunder and lightning. Many trees were uprooted. The Hudson Valley Railway was seriously affected.	New York Times
Severe Storm July 5, 1914	Countywide	A woman was struck by lightning and killed. Several barns were set on fire due to the lightning. Crops were badly damaged in Fulton, Hamilton, Saratoga and Montgomery Counties. The storm was especially severe in Saratoga County. Heavy rains caused flooding and hailstones covered fields. Telephone and telegraph wires were damaged and communication was cut off in some locations.	New York Times
Tornado (F2) June 16, 1974	Countywide	F2 tornado struck the County. The County had approximately $250 K in property damage.	The Tornado Project, SHELDUS
Tornado (F1) July 29, 1974	Countywide	F1 tornado struck the County.	The Tornado Project
Tornado (F1) May 9, 1978	Countywide	F1 tornado struck the County.	The Tornado Project
Tornado (F1) November 16, 1989	Countywide	F1 tornado struck the County. The County had one reported injury and approximately $50 K in property	The Tornado Project, SHELDUS

Event Name / Date	Location	Losses / Impacts	Source(s)
		damage.	
Lightning April 13, 1994	Northumberland	A lightning strike hit a house in the Town of Northumberland, igniting a fire, which damaged the roof and ceilings of a home. Approximately $50 K in property damage.	NOAA-NCDC
TSTM August 20, 1994	Countywide	During the afternoon of the 20th, a severe TSTM hit Saratoga County. Winds downed trees and power lines and large hail fell. Thousands of people were without power. The County had approximately $5 K in property damage.	NOAA-NCDC
TSTM June 2, 1995	Multi-County	A cold front caused severe TSTMs over eastern New York State. Winds downed trees and power lines across several counties in the State, including Saratoga County. In the County, trees fell onto a home in the Town of Wilton, causing extensive damage. In Saratoga Springs, a tree limb fell on a motorcyclist. Saratoga County had approximately $110 K in property damage and one injury.	NOAA-NCDC, SHELDUS
Severe Storm July 14-15, 1995 (“Ontario-Adirondack Derecho”)	Multi-County	The thunderstorm gust front hit the bridge and a gust of 90 mph was measured. Sustained winds above 80 mph continued on the bridge for several minutes, which was the beginning of the “Ontario-Adirondacks Derecho”. This system caused hundreds of millions of dollars in damage, several deaths, and many injuries as it moved from the Great Lakes region to the Atlantic coast. Overall, New York State had five deaths, 11 injuries and nearly $400 million in damages. Saratoga County experienced $112 K in property damage.	SPC, NOAA-NCDC, SHELDUS
High Winds October 5-6, 1995 (Remnants of Hurricane Opal)	Multi-County	Remnants of Hurricane Opal brought heavy rains and strong winds to parts of central and eastern New York State. In Saratoga Springs, large tree limbs fell, damaging four cars. Saratoga County had approximately $20 K in property damage.	NOAA-NCDC, SHELDUS
Severe Storm January 18-20, 1996 (FEMA DR-1095)	Multi-County	See FEMA Disaster Declarations (Table 5.4.3-5)	NRCC, NOAA-NCDC, Lumia, NYSDPC, SHELDUS, NYSEMO, FEMA
TSTM June 11, 1996	Clifton Park	A couple of severe TSTMs produced hail and damaging winds in the Town of Clifton Park, downing power lines and causing approximately $5 K in property damage.	NOAA-NCDC, SHELDUS

Event Name / Date	Location	Losses / Impacts	Source(s)
Strong Winds July 19-20, 1996	Multi-County	Strong winds generated in the area due to a low pressure system. The winds downed trees and power lines across parts of eastern New York State. In Saratoga Springs, a large willow tree was knocked down in Congress Park. Power outages were widespread. Saratoga County had approximately $8 K in property damage.	NOAA-NCDC, SHELDUS
High Wind November 8, 1996	Multi-County	Across eastern New York State, damaging winds struck several counties, including Saratoga County. Over 3,000 customers in the Mid-Hudson Valley and southern Catskills lost power. Across Saratoga County, trees and power lines were down in several locations, including the Towns of Wilton, Hadley and Malta, and the Village of Schuylerville. Saratoga County had approximately $8 K in property damage.	NOAA-NCDC, SHELDUS
High Wind December 1, 1996	Multi-County	Damaging winds hit eastern New York State, downing trees and power lines in several counties, including Saratoga County. Approximately 2,000 people were without power in the Capital District. Damage was most widespread in Saratoga, Warren and Rensselaer Counties. In Waterford, a tree fell on a trailer home and truck. Saratoga County had approximately $12 K in property damage.	NOAA-NCDC, SHELDUS
High Wind February 27, 1997	Countywide	High winds were produced across eastern New York State. In northern Saratoga County, in Corinth, high winds downed trees and power lines, causing over 3,000 people to be without power. The County had approximately $8 K in property damage.	NOAA-NCDC, SHELDUS
TSTM July 15, 1997	Countywide	Scattered severe TSTMs developed over the region on the 15th. In Saratoga County, near Gurn Springs, a 70-foot steel sign crashed to the ground, three trailers were overturned at the Freedom RV Outlet, and a RV was flipped over at the Freedom RV Outlet. Extensive hail damage was also reported at the Freedom RV Outlet. Camp Saratoga had 2,000 trees uprooted, the galvanized roofing ripped off the mess hall, utility lines were downed and minor damage was reported to the medical lodge. A person was struck by lightning in the Village of South Glens Falls. The County had approximately $277 K in property damage and $30 K in crop damage.	NOAA-NCDC, SHELDUS
TSTM	Countywide	Severe TSTMs were produced in Herkimer, Saratoga,	NOAA-NCDC, SHELDUS

Event Name / Date	Location	Losses / Impacts	Source(s)
July 17, 1997		Washington, and Montgomery Counties. In the Village of Round Lake, a station wagon was totaled when a tree fell on top of it. In Stillwater, winds downed trees onto a trailer. The County had approximately $43 K in property damage.	
Hail August 22, 1997	Countywide	Afternoon TSTMs produced hail in Fulton, Columbia, and Saratoga Counties. In Saratoga Springs, hail covered the ground in many areas and two trucks were crushed when a large branch fell down due to wind. Winds also downed trees in Saratoga County. Damages were between approximately $25 K and $30 K for the County.	NOAA-NCDC, SHELDUS
Severe TSTMS / Tornadoes May 29-31, 1998 (FEMA DR-1222)	Multi-County	See FEMA Disaster Declarations (Table 5.4.3-5)	FEMA, NOAA-NCDC, SHELDUS, Stewart, NYSDPC, LeDuff
Severe TSTMs July 23, 1998	Multi-County	Severe TSTMs hit Saratoga and Washington Counties. The storms brought down trees and power lines. Nickel sized hail fell in the Town of Malta. The storms also produced frequent lightning strikes. Saratoga County had between approximately $15 K and $19 K in property damage.	NOAA-NCDC, SHELDUS
Severe Storm September 7, 1998	Multi-County	A derecho developed and moved across northwestern New York State and then traveled east through Rochester and Syracuse then into the Mohawk River Valley. It continued into Vermont and New Hampshire. Significant TSTM wind damage was reported from Rochester and Syracuse east through Gloversville and Charlton (Saratoga County). Winds were measured at 80 to 90 mph. Montgomery and Herkimer Counties were declared disaster areas. In Charlton, a cemetery was damaged. Widespread wind damage was reported in the Hamlet of Burnt Hills (in the Town of Ballston) and the Village of Ballston Spa. In the Village of Schuylerville, ¾-inch hail was reported, along with 50 mph winds. At the height of the storm, as many as 30,000 people were without power. Saratoga County had approximately $59 K in property damage.	NOAA-NCDC, NWS, SHELDUS, CBS 6 Albany
TSTM / Hail September 21, 1998	Multi-County	During the afternoon of the 21st, a low pressure system produced a supercell in southern Saratoga County. It then moved into northern Rensselaer County. In Saratoga County, many trees were down in the City of Mechanicville.	NOAA-NCDC, SHELDUS

Event Name / Date	Location	Losses / Impacts	Source(s)
		One tree fell on top of a car and caused minor injuries. In the Town of Halfmoon, a roof was blown off a modular home. Quarter size hail fell in Mechanicville. Saratoga County experienced approximately $31 K in property damage.	
Lightning June 28, 1999	Halfmoon	Lightning struck a home in the Town of Halfmoon that started an electrical fire. Multiple lightning strikes resulted in downed trees and wire and power outages throughout the County. Approximately $50 K in property damage.	NOAA-NCDC, SHELDUS
Heavy Rain / Winds September 16-17, 1999 (Remnants of Tropical Storm Floyd)	Multi-County	As the remnants of Tropical Storm Floyd passed through eastern New York State, strong winds caused numerous power outages and downed trees. The storm also brought heavy rain to the area, with totals ranging between 3 and 6 inches. Saratoga County reported many downed trees and power lines. The County had approximately $411 K in property damage.	NOAA-NCDC, NWS, SHELDUS
TSTM May 18, 2000	Multi-County	This was the largest outbreak of severe storms in New York State in over two years. They struck over eastern New York State. Most of the damage was due to strong, TSTM winds, but there was almost hail damage reported. The storms also brought two confirmed tornadoes. Winds from the storms knocked down large trees and power lines in several counties, including Saratoga. In Saratoga County, a microburst sheared off eight 40-foot trees in the Hamlet of Ballston Lake (in the Town of Ballston). One tree damaged a house. In the Town of Clifton Park, trees and limbs fell. The County had approximately $113 K in property damage.	NOAA-NCDC, SHELDUS
Severe Storm June 2, 2000	Multi-County	A powerful cold front across eastern New York State caused widespread severe weather and damages across the area. In all, over 40 separate events were reported, including straight-line winds and hail. The storms were reported in all New York State counties except for Warren and Hamilton Counties. Saratoga County was especially hit hard, with many municipalities reporting widespread damage. In the Village of Round Lake, trees were blown down on top of a house. In the Hamlet of Rock City Falls (in the Town of Milton), trees were blown down, trapping people inside a car. At Saratoga Lake, a boat was overturned. In the Town of Galway, two mobile homes	NOAA-NCDC, SHELDUS

Event Name / Date	Location	Losses / Impacts	Source(s)
		were destroyed. In the Village of Ballston Spa, a mobile home was crushed by a fallen tree. In the Hamlet of Milton Center, trees and power lines were down and homes were damaged and five mobile homes were severely damaged in the Stockade Mobile Home Park. Some roads were closed in the Towns of Galway and Milton. In the Town of Stillwater, a large tree fell on a bus. At the height of the storm, as many as 30,000 people were without power. Saratoga County had over $1.5 M in property damage.	
High Wind September 21, 2000	Eastern New York State	Micro severe weather occurred within a larger area that produced extensive damage. A gustnado hit Saratoga County, causing extensive damage to the Curtis Lumber Facility in Ballston Spa. The rain that hit Ballston Spa produced the gustnado. In the Town of Clifton Park, 10 to 15 minute duration of high winds struck the town, with peak gusts estimated at 55 mph. This storm caused 2 injuries and approximately $268 K in property damage.	NOAA-NCDC, CBS 6 Albany, SHELDUS
Heavy Rain / TSTM July 14-16, 2001	Multi-County	Scattered TSTMs hit the area, some heavy at times. The storms brought heavy rain to the area. Totals for Saratoga County ranged between 2.5 inches and 3.97 inches.	CBS 6 Albany
Severe Storm May 28, 2001	Multi-County	Widespread showers and TSTMs hit eastern New York State. Dime to golfball-sized hail was noted across Albany County and in southern Saratoga County. A severe TSTM produced damaging winds in the County. In the hamlet of Rexford, utility poles were down. Power lines were down in the Towns of Stillwater and Clifton Park. In southern portions of the County, hail significantly damaged two apple orchards, in the Town of Clifton Park and in the Hamlet of Rexford. Saratoga County had approximately $45 K in property damage and $300 K in crop damage.	NOAA-NCDC, SHELDUS
TSTM July 4, 2001	Multi-County	TSTMs brought down trees and power lines in Malta and Schuylerville. In the Village of Schuylerville, a tree fell onto a home and dime size hail fell. The heavy rains from the storm caused a mudslide on Route 9P near Brown Road in the Town of Stillwater, closing the road. Saratoga County had approximately $68 K in property damage.	NOAA-NCDC, SHELDUS
TSTM August 9, 2001	Multi-County	A series of severe TSTMs struck the area, leaving a large swath of damage. In the Town of Stillwater, a 75 mph wind gust and downed trees were observed. Scattered downed	NOAA-NCDC, SHELDUS

Event Name / Date	Location	Losses / Impacts	Source(s)
		trees were reported in the Towns of Malta and Clifton Park, the City of Saratoga Springs and the Hamlet of Saratoga Lake. Thirty roads were temporarily closed throughout the City of Saratoga Springs. In the Hamlet of Saratoga Lake, a large tree crushed three boats. The County had approximately $151 K in property damage.	
High Wind March 3, 2002	Multi-County	Rain storms produced strong winds in Saratoga and Washington Counties. In Saratoga County, wind gusts blew a roof off of a home in the Town of Greenfield. A tree blew through a house in Town of Halfmoon and numerous trees and wires were down in the Town of Corinth. Saratoga County had approximately $50 K in property damage ($25 K in wind damage).	NOAA-NCDC, SHELDUS
Severe Storm June 5, 2002	Multi-County	This was the second major severe weather outbreak in the past week to strike eastern New York State and western New England. Damage was most widespread in Saratoga County, near the Village of Round Lake and the hamlet of Maltaville. A NWS team found a path of significant damage which began near the hamlet of Maltaville and continued to the Town of Stillwater. A TSTM downburst hit this area, causing damage. Damage in Saratoga County included down trees and power lines in the Town of Malta, a tree blown on a house in the hamlet of Malta Ridge, trees down in the Village of Round Lake and the Town of Malta, and hail in the Town of Stillwater. Saratoga County had approximately $172 K in property damage.	NOAA-NCDC, NWS, SHELDUS
Severe Storm May - June 2004 (FEMA DR-1534)	Multi-County	See FEMA Disaster Declarations (Table 5.4.3-5)	NWS, SHELDUS, CBS 6 Albany
High Wind February 17, 2006	Multi-County	Strong winds struck across eastern New York State. Two people were killed and hundreds of thousands of residents in upstate New York State lost electricity, due to the high winds. Many areas in Saratoga County were affected. In the Town of Edinburg, a roof was blown off a mobile home, trapping people inside. Wind gusts of over 98 mph were measured at the Saratoga County Airport in the hamlet of Milton Center. A roof was blown off a building in the City of Saratoga Springs. Trees and wires were down in the Town of Clifton Park. A County maintenance worker was killed when a tree struck his truck while driving through the City	NOAA-NCDC, NWS, Foderaro

Event Name / Date	Location	Losses / Impacts	Source(s)
		of Saratoga Springs.	
Heavy Rain / Winds October 28-29, 2006	Multi-County	A low pressure system brought heavy rains, flooding, damaging winds and lake effect snow to the region. Most wind gusts in the area exceeded 60 mph. The winds downed tree limbs and power lines, causing power outages. In the Town of Clifton Park, trees and wires were down. In the Village of South Glens Falls, a store window was blown out. Rainfall totals for the County ranged between 1.30 inches and 2.68 inches.	NOAA-NCDC, NWS

Note (1): The intensity of tornado events to affect Saratoga County is measured by the Fujita Scale in this Table, which was decommissioned on February 2007. NOAA-NCDC storm query indicated that Saratoga County has experienced 532 severe storm events between January 1, 1950 and November 30, 2008 (including Thunderstorms, Hail, Wind, Hurricane, Lightning, and Tornado events). However, not all of these events were identified in this table due to a lack of detail and/or their minor impact upon the County.

Note (2): Monetary figures within this table were U.S. Dollar (USD) figures calculated during or within the approximate time of the event. If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of inflation.

* According to many sources, these events were known as Nor'easters, therefore, they are not discussed further in this hazard profile and are further mentioned in Section 5.4.2 (Severe Winter Storm) and the flooding impact of the events are mentioned in Section 5.4.1 (Flood)

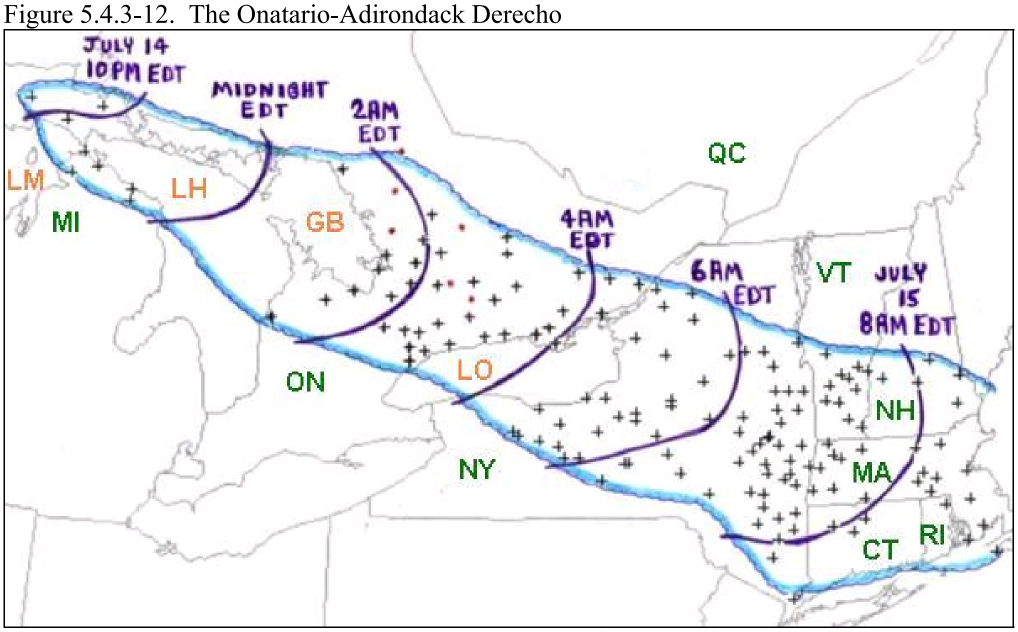
CBS	Central Broadcasting Station
DR	Federal Disaster Declaration
EM	Federal Emergency Declaration
F	Fujita Scale (F0 – F5)
FEMA	Federal Emergency Management Agency
HPC	Hydrometeorological Prediction Center
K	Thousand ($)
M	Million ($)
NCDC	National Climate Data Center
NOAA	National Oceanic Atmospheric Administration
NWS	National Weather Service
NYS	New York State
NYS DPC	New York State Disaster Preparedness Commission
NYSEMO	New York State Emergency Management Office
SHELDUS	Spatial Hazard Events and Losses Database for the U.S.
SPC	Storm Prediction Center (NOAA)
TSTM	Thunderstorm
U.S.	United States
USD	US Dollars
USGS	U.S. Geological Survey

Further descriptions of select severe storm events that have impacted Saratoga County are provided below with details regarding their impact (where available). These descriptions are provided to give the reader a context of the severe storm events that have affected the County and to assist local officials in locating event-specific data for their municipalities based on the time and proximity of these events. Many severe storm events resulted in major flooding throughout the County; therefore, the flood impacts of these events are further mentioned in Section 5.4.1 (Flood). Also, certain severe storm events have been classified as Nor'Easters; therefore, they are not discussed further in this hazard profile and are further included in Section 5.4.2 (Severe Winter Storm).

Monetary figures within the following event descriptions were U.S. Dollar (USD) figures calculated during or within the approximate time of the event (unless present day recalculations were made by the sources reviewed). If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of increased inflation.

July 14-15, 1995 ("The Ontario-Adirondack Derecho"): On the evening of July 14th, thunderstorms producing severe weather were occurring over upper Michigan and adjacent portions of Ontario near Sault Saint Marie. By late evening, the storms developed into a bowing line just northwest of the Mackinac Bridge. The thunderstorm gust front hit the bridge and a gust of 90 mph was measured. Sustained winds above 80 mph continued on the bridge for several minutes, which was the beginning of the "Ontario-Adirondacks Derecho". This system caused hundreds of millions of dollars in damage, several deaths, and many injuries as it moved from the Great Lakes region to the Atlantic coast (SPC, Date Unknown). Figure 5.4.3-12 illustrates the storm path of this system.

Figure 5.4.3-12. The Onatario-Adirondack Derecho



Source: SPC, Date Unknown
Note: Curved purple lines represent the approximate locations of the "gust front". "+" symbols indicate the locations of wind damage or wind gusts above severe limits (58 mph or greater). Red dots represent tornado occurrences.

In Canada, as the system crossed northern Lake Huron and Georgian Bay, it grew in scale and the derecho winds affected a large area of southern Ontario during the early morning of July 15th. Wind gusts were calculated at 100 mph or more in some locations, causing extensive damage. Several brief tornadoes were associated with this system as well. Most of the tornadoes were weak, but a strong F2 tornado hit the Town of Bridgenorth, destroying a marina and damaging 20 homes. Particularly hard hit was a portion of south central Ontario, with some of the severe damage in the Towns of Huntsville, Bracebridge, Orillia, Minden and Fenelon Falls, all located in Ontario, Canada. Power outages in these areas lasted from several days to a week. According to a report from the Insurance Bureau of Canada, this system resulted in $53 million in 1995 Canadian dollars (SPC, Date Unknown).

As the "Ontario-Adirondacks Derecho" entered New York State on July 15th, severe wind damage continued in this area. Winds were estimated to be 100 mph or greater at several points along a band from Jefferson County and western St. Lawrence County. In the Adirondack Mountain region, over 30 campers and hikers in the area had to be removed by helicopter since their paths out of the forest were blocked by thousands of fallen trees. The NYS DEC estimated about 900,000 acres of forest were damaged with a value loss of timber over $200 million. In the more populated areas of central and eastern New York State, almost $190 million in damage was done to structures and vehicles. Many mobile homes were overturned and numerous homes and businesses were damaged. Several hundred thousands of people were without power due to the powerful derecho winds. Overall, New York State had five deaths, 11 injuries and nearly $400 million in damages (SPC, Date Unknown).

According to NOAA-NCDC and SHELDUS, Saratoga County suffered approximately $102,000 in property damages (NCDC, 2008; Hazards and Vulnerability Research Institute, 2007).

January 18-20, 1996 (FEMA DR-1095): Unseasonably warm air ahead of a storm overspread the Northeast on January 18th and 19th. Temperatures reached the mid-50s to the mid and upper-60s. Melting snow and ice break-up during the evening of the 18th caused ice jam flooding across scattered areas of western Pennsylvania and western New York State. The storm brought over two inches of rain from northern West Virginia through Central Pennsylvania and over the Catskill Mountains in New York State. The worst of the flooding began on the 19th, due to the heavy rains causing rapid snow melt. Many drainage basins were overwhelmed and widespread flooding broke out. Thousands of people were forced to evacuate their homes in parts of Ohio, Pennsylvania, West Virginia, New Jersey, Maryland and New York (NRCC, 1996).

The storm produced damaging winds across eastern New York State, resulting in reports of downed trees, limbs, and power lines, producing $100 million in property damage (NCDC, 2007). Overall, this event claimed 10 lives, stranded hundreds of people, damaged or destroyed thousands of homes and businesses, and closed hundreds of roads. The most severely affected region was the Catskill Mountains. More than 4.5 inches of rain fell on at least 45 inches of snow in the Catskill Mountain region during this event and caused major flooding throughout the southeastern section of New York State (Lumia, 1998; NYSDPC, 2008).

In Saratoga County, the severe thunderstorms downed trees in the Town of Milton, causing approximately $5,000 in property damage (NCDC, 2007). According to SHELDUS, Saratoga County had another $30,000 in property damage due to wind. The majority of damage was due to flooding along the major waterways of the County. The flood impact and losses of this event are further discussed in more detail in Section 5.4.1 (Flood). Overall, according to NOAA-NCDC and SHELDUS, Saratoga County experienced over $10 million in total property damages from flooding and wind during this event (NCDC, 2008; Hazards and Vulnerability Research Institute, 2007).

This storm resulted in a FEMA Disaster Declaration (FEMA DR-1095) on January 24, 1996. Through this declaration, the following 41 counties were declared eligible for Federal and State disaster funds: Albany, Allegany, Broome, Cattaraugus, Cayuga, Chemung, Chenango, Clinton, Columbia, Cortland, Delaware, Dutchess, Essex, Franklin, Greene, Herkimer, Jefferson, Lewis, Livingston, Madison, Montgomery, Onondaga, Ontario, Orange, Otsego, Putnam, Rensselaer, St. Lawrence, Saratoga, Schenectady, Schoharie, Schuyler, Steuben, Sullivan, Tioga, Tompkins, Ulster, Warren, Washington, Wyoming and Yates (NYSEMO, 2006; FEMA, 2008; NYSDPC, 2008). Disaster assistance for all counties affected in the State totaled approximately $16.7 million in individual assistance and $103.7 million in public assistance (1997 USD). Saratoga County received $328,494 in individual assistance and $1.3 million in public assistance (1997 USD) (Lumia, 1998).

May 29 - 31, 1998 (Tornado Outbreak) (FEMA DR-1222): During the afternoon of May 29th, a line of fast moving thunderstorms crossed eastern New York State and caused damage in every county in its path. The storms resulted in one fatality and three injuries. Across the region, the damaging winds knocked out power to over 40,000 customers, broke several telephone poles, and damaged dozens of homes due to fallen trees and large branches. Damage was widespread in Montgomery, Fulton, Saratoga, Warren, and Washington Counties (NOAA-NCDC, 2008). Reports of wind damage and down power lines and trees were reported for the County (CBS 6 Albany, 1998). According to NOAA-NCDC and SHELDUS, Saratoga County experienced approximately $31,000 in property damage due to this storm.

A second round of storms struck on May 31st. A major severe weather outbreak hit eastern New York State, resulting in three tornadoes and severe thunderstorm damage in every county in this area. The most significant tornado occurred in Saratoga County and northern Rensselaer County. A tornado watch was issued for all of eastern New York State and western New England. A supercell rapidly intensified and moved east at 50 mph into Saratoga County. This supercell produced a F3 tornado that moved through the City of Mechanicville and Town of Stillwater in Saratoga County and dissipated over Shaftsbury, Vermont.

In Saratoga County, the tornado touched down at Ushers Road in the Town of Halfmoon and moved eastward into the City of Mechanicville. It then tracked over the Viall Hill section of Mechanicville and continued east into the Riverside area of Stillwater. The tornado then crossed over the Hudson River into Rensselaer County where it decreased to a F2. It destroyed the DiSiena Furniture Company and severely damaged or destroyed many homes, businesses and warehouses in Saratoga County. Figures 5.4.3-13 through 5.4.3-15 show the after effects of this tornado (NOAA-NCDC, 2008; NWS, 2001; CBS 6 Albany, 1998).

Figure 5.4.3-13. Home in Mechanicville

Source: Steve LaPointe, 1998

Figure 5.4.3-14. Small Section of Viall Hill in the City of Mechanicville Completely Destroyed

Source: Steve LaPointe, 1998

Figure 5.4.3-15. Destroyed Home in Saratoga County

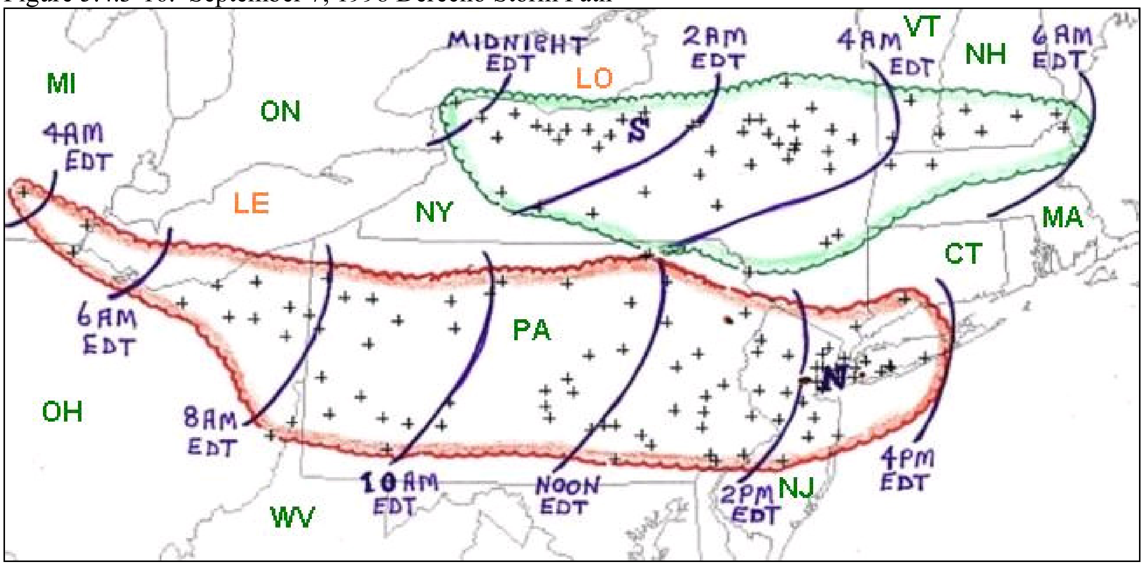
Source: Steve LaPointe, 1998

In Saratoga County, approximately 35 homes were destroyed and 230 homes were damaged. Power was not restored to parts of the region for three to four days (NYSDPC, 2008). According to SHELDUS and NOAA-NCDC, Saratoga County had over $60 million in property damage from this event.

This event resulted in a FEMA Disaster Declaration (FEMA DR-1222) on June 19, 1998 (FEMA, 2007). Through this declaration, public assistance was given to the following New York State counties: Broome, Chenango, Otsego, Rensselaer, Saratoga, and Wyoming. According to Governor George E. Pataki, the tornadoes created widespread power outages, disruption of vital transportation systems and public safety systems, and agricultural damage to 15 counties (Pataki, 1998). New York State had an estimated $6.9 million in total eligible damages (NYSDPC, 2008).

September 7, 1998 ("Syracuse Derecho of Labor Day 1998"): By midnight of September 7th, a cluster of fast-moving thunderstorms developed. The cluster swept east through Rochester and Syracuse and then into the Mohawk River Valley during the early morning hours of the 7th. This storm was known as a derecho and it continued into southern sections of Vermont and New Hampshire. Significant thunderstorm wind damage was reported from Rochester (Monroe County) and Syracuse (Onondaga County) east through Gloversville (Fulton County) and Charlton (Saratoga County). Winds of speeds between 80 and 90 mph were measured as the storm passed. During the afternoon on September 7th, another derecho hit the New York City Metropolitan Area including Long Island (NWS, 1998). Figure 5.4.3-16 displays the path of the derecho throughout the northeast U.S.

Figure 5.4.3-16. September 7, 1998 Derecho Storm Path



Source: SPC, Date Unknown
Note: The two derecho events are outlined in green and red. The green indicates the Syracuse Derecho and the red indicates the New York City derecho. Curved purple lines represent the approximate locations of the "gust fronts" at two hourly intervals. "+" symbols indicate the locations of wind damage or wind gusts above severe limits (58 mph or greater). Red dots and paths indicate tornado events. A "gust front" is the leading edge of the downdraft (downward moving air) from a thunderstorm.

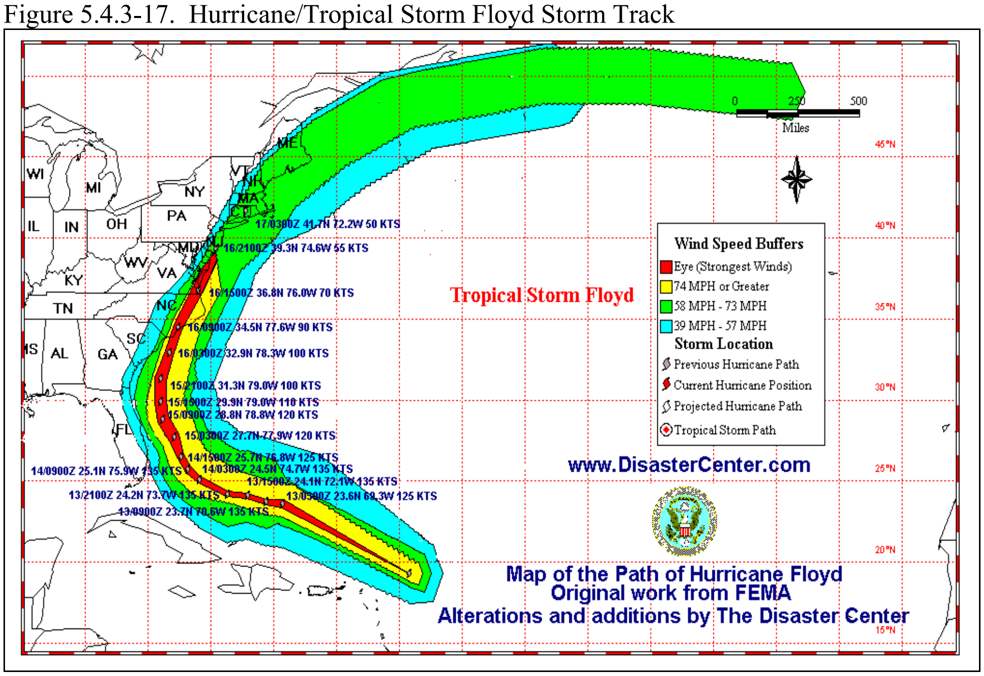
Along the storm track, tens of thousands of trees were blown down and over 100 homes and businesses were damaged. Many homes and businesses experienced power outages, some without power for a week (SPC, Date Unknown). Some of the worst damage areas were noted in a band across western and central New York State, within the vicinity of Rochester, Syracuse, and Utica. A total of three people were killed and ten were injured at the New York State Fairgrounds in Syracuse. Wind gusts were measured at 89 mph at the Rochester Airport and 77 mph at the Syracuse airport. Winds were estimated to have reached 115 mph in the areas with the worse damage. Along the storm track of the derecho, tens of thousands of trees were blown down and over 1,000 homes and businesses were damaged. Hundreds of thousands were without power, some without power for a week. Total damages in New York State were estimated at $130 million (1998 USD) (SPC, Date Unknown).

In Saratoga County, widespread wind damage was reported in the Hamlet of Burnt Hills and Saratoga Springs. Three-quarter inch hail and 50 mph winds were reported in Schuylerville (CBS 6 Albany, 1998). According to NOAA-NCDC and SHELDUS, Saratoga County experienced approximately $59,000 in property damage from this event (NCDC, 2008; Hazards and Vulnerability Research Institute, 2007).

This storm resulted in a FEMA Disaster Declaration (FEMA DR-1244) on September 11, 1998; however, Saratoga County was not a declared county. Through this declaration, individual and public assistance was given to Cayuga, Fulton, Herkimer, Madison, Monroe, Onondaga, Oneida, Ontario and Wayne Counties (FEMA, 2007; NYSEMO, 2006). Over $36 million was given out in public and individual assistance to those affected counties (NYSDPC, 2008).

September 16-17, 1999 (Hurricane/Tropical Storm Floyd): According to the NOAA NHC, this event was a large and intense storm that pounded the central and northern Bahama Islands, seriously threatened Florida, struck near the coast of North Carolina and moved up the east coast of the U.S. into New England as a tropical storm. It neared the threshold of a Category 5 on the Saffir/Simpson Hurricane Scale as it approached the Bahamas, and caused a flood disaster of immense proportions in the eastern U.S., particularly from the eastern coast of North Carolina through New Jersey (Pasch et al., 1999). Much of Floyd's impact was due to heavy rainfall, creating major losses from floodwaters throughout the eastern U.S. Common rainfall totals ranged between 4 and 12 inches (NWS, 1999). Ten states were declared major disaster areas, which included Connecticut, Delaware, Florida, Maryland, New Jersey, New York, North Carolina, Pennsylvania, South Carolina, and Virginia (NCDC, 2000). Figure 5.4.3-17 illustrates the storm track of Floyd.

Figure 5.4.3-17. Hurricane/Tropical Storm Floyd Storm Track



Source: The Disaster Center, 1999

As the remnants of Floyd passed by eastern New York State, strong winds pummeled the region with numerous reports of power outages and downed trees. Some of the reported downed trees were the result of the soft ground due to the excessive amount of rain (NWS, 1999). According to the NWS, rainfall totals for Saratoga County ranged between 4.36 inches (Hamlet of Conklingville, in the Town of Day) and 5.5 inches (Town of Clifton Park) (NWS, 1999). Most damage in Saratoga County was due to wind damage. In the Lake George-Saratoga Region, over 25,000 people were without power. Cost estimates of property damage in Saratoga County were unavailable in the materials reviewed to develop this plan.

This storm resulted in a FEMA Disaster Declaration (FEMA DR-1296) on September 19, 1999; however, Saratoga County was not a declared county.

May through September 2000: Between May and September 2000, multiple severe storm events occurred throughout New York State, resulting in significant flooding and over $34.6 million in damage throughout the State. The flood impact and losses of this event are discussed in more detail in Section 5.4.1 (Flood).

The first series of storms began on May 18, 2000. A strong cold front crossed eastern New York State, bringing very strong winds. This system spawned a line of thunderstorms, producing the largest outbreak of severe weather across eastern New York State in nearly two years. The vast majority of damage was from thunderstorm winds, along with hail damage and two confirmed tornadoes. Thunderstorm winds knocked down large trees and power lines in Albany, Columbia, Greene, Montgomery, Saratoga, Schoharie, and Ulster Counties. In Saratoga County, a microburst sheared off eight 40-foot trees in the hamlet of Ballston Lake. A tree damaged a home. In the Town of Clifton Park, trees and limbs fell (NOAA-NCDC, 2007). In the Cities of Mechanicville and Saratoga Springs, within 10 minutes, over one-inch of rain fell. The Hamlet of Greenfield Center reported one-inch diameter hail (CBS 6 Albany, 2000). According to NOAA-NCDC and SHELDUS, Saratoga County had approximately $113,000 in property damage due to this storm (NCDC, 2008; Hazards & Vulnerability Research Institute, 2007).

The second series of storms hit the area on June 2, 2000. A powerful cold front moved across eastern New York State, bringing an unstable air mass in front of a cold front. This generated straight line thunderstorm winds and hail and caused widespread severe weather damage. Overall, over 40 separate events of severe weather were reported. Saratoga County was hit hard during this event. Many of its municipalities reported widespread damage. In the Village of Round Lake, trees were blown down and trapped people inside a car. At Saratoga Lake, a boat was overturned. In the Town of Galway, two mobile homes were destroyed. In the Village of Ballston Spa, a mobile home was crushed be a tree. In Milton Center, power lines and trees were down, several homes and mobile homes were damaged. Five mobile homes in the Stockdale Mobile Home Park were severely damaged. In the Town of Stillwater, a large tree fell on a bus. Some roads were closed in the Towns of Galway and Milton. According to NOAA-NCDC and SHELDUS, the County had approximately $1.5 million in property damage from this storm (NCDC, 2008; Hazards & Vulnerability Research Institute, 2007).

On August 3, 2000, numerous thunderstorms developed, producing dime-size hail to a couple of New York State counties. Many other reports were in relation to wind damage. Many trees and power lines were down in several counties. In Saratoga County, dime size hail was reported in Stillwater. Trees and wires were down at the Hamlet of Coveville (in the Town of Saratoga), the Town of Clifton Park and City of Saratoga Springs. According to NOAA-NCDC and SHELDUS, the County had approximately $40,000 in property damage (NCDC, 2008; Hazards & Vulnerability Research Institute, 2007).

On September 2, 2000, slow moving thunderstorms developed across eastern New York State during the afternoon. The storms produced very heavy rain and one cell became severe as it moved across Saratoga County. Winds from this storm brought down trees in Ballston Spa. According to NOAA-NCDC and SHELDUS, the County had approximately $12,000 in property damage (NCDC, 2008; Hazards & Vulnerability Research Institute, 2007).

On September 21, 2000, a line of thunderstorms became severe as they moved into eastern New York State. The most damage was seen in Ballston Spa. A strong microburst, with winds between 75 and 100 mph, covered an area 75 yards wide and 500 yards long. The microburst went through the Curtis Lumber facility, where winds destroyed a portion of the barn structure. The roof of the building was blown off and lumber was scattered across the yard. A man was critically injured at the lumber yard when a piece of roof blew into the cab of a parked truck. According to NOAA-NCDC and SHELDUS, Saratoga County had approximately $268,000 in property damage (NCDC, 2008; Hazards & Vulnerability Research Institute, 2007).

These storms resulted in a FEMA Declaration Disaster (FEMA DR-1335) on July 21, 2000; however, Saratoga County was not a declared county. Through this declaration, the following 27 counties were declared eligible for Federal and State disaster funds: Albany, Allegany, Cattaraugus, Columbia, Dutchess, Erie, Essex, Greene, Herkimer, Lewis, Livingston, Madison, Montgomery, Niagara, Oneida, Onondaga, Orleans, Otsego, Rensselaer, Schenectady, Schoharie, Steuben, Sullivan, Tioga, Tompkins, Ulster and Yates (FEMA, 2003).

June 5, 2002: During the evening of June 5th, a second major severe weather outbreak within a week struck eastern New York State and western New England. Damage was most widespread in Saratoga County, near Round Lake and Maltaville. The storms first developed in Saratoga County then headed southwest toward the Schoharie and Mohawk Valleys.

A macroburst developed in Saratoga County, beginning in the Town of Malta and continuing through Ballston Spa and Stillwater. It then continued into the Schaghticoke region of Rensselaer County, as well as southern Washington County. The damage was in a fan-like pattern up to a half mile wide, which is evidence of straight line winds. In Saratoga County, a house's roof was blown off in the Village of Ballston Spa. In the Village of Round Lake, trees fell on a house. Winds from this event were estimated to be as high as 115 mph. Hail and wind damage was reported in several areas throughout the County (NWS, 2002; NOAA-NCDC, 2008). According to NOAA-NCDC and SHELDUS, Saratoga County had approximately $172,000 in property damage (NCDC, 2008; Hazards & Vulnerability Research Institute, 2007).

May through June 2004 (FEMA DR-1534): Within a 24-hour period, between May 23rd and May 24th, three separate outbreaks of severe thunderstorms developed over eastern New York State. These storms produced strong winds, large hail and flash flooding throughout the area. On May 24th, three waves of severe thunderstorms struck the area, with each storm being more intense and widespread. The first produced isolated severe weather around sunrise on the 24th. During the late morning, the second storm occurred as an organized line of thunderstorms moving across eastern New York State and western New England. Between 3pm and 4pm on the 24th, the third round of storms hit, producing two confirmed tornadoes in Broome and Delaware Counties (NWS, 2009).

In Saratoga County, lightning struck a chimney of a house, causing $1,000 in property damage. In the Village of Round Lake, trees and power lines were down on Eastline Road. In the Town of Galway, hail and flooding caused approximately $80,000 in property damage. Hail was also reported in many other parts of the County. Overall, according to NOAA-NCDC and SHELDUS, Saratoga County had approximately $81,000 in property damage from the May 24th series of storms (NCDC, 2008; Hazards & Vulnerability Research Institute, 2007).

The next round of severe storms struck the area in early June. An outbreak of severe storms on June 9th produced frequent lightning and 32 reports of wind damage across eastern New York State. Several rounds of strong thunderstorms caused two brief F0 tornadoes in St. Lawrence County. The storms brought wind damage and hail to many areas (CBS 6 Albany, 2004).

In Saratoga County, trees and power lines were down in the Hamlet of Harmony Corners (in the Town of Charlton), where a chimney was blown off a house as well (CBS 6 Albany, 2004). According to NOAA-NCDC and SHELDUS, the County had approximately $5,000 in property damage (NCDC, 2008; Hazards & Vulnerability Research Institute, 2007).

These storms resulted in a FEMA Declaration Disaster (FEMA DR-1534) on August 3, 2004. Through this declaration, the following 14 counties were declared eligible for Federal and State disaster funds: Allegany, Cattaraugus, Chautauqua, Delaware, Erie, Hamilton, Herkimer, Ontario, Saratoga, Schoharie, Steuben, Ulster, Washington and Yates. Over $6.3 million was approved for Public Assistance projects in these affected counties. The money was used towards debris removal; repair of roads and bridges; repair or replacement of buildings; repair and restoration of parks, playgrounds, pools and cemeteries;

certain administration fees; and emergency protective measures taken before, during and after a disaster (FEMA, 2004).

Probability of Future Events

In Section 5.3, the identified hazards of concern for Saratoga County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records and input from the County Planning Committee, the probability of occurrence for severe storms in Saratoga County is considered "frequent", as presented in Table 5.3-3 in Section 5.3.

It is estimated that Saratoga County will continue to experience direct and indirect impacts of severe storms annually that may induce secondary hazards such as flooding, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences.

The Role of Global Climate Change on Future Probability

Global climate change poses risks to human health and to terrestrial and aquatic ecosystems. Important economic resources such as agriculture, forestry, fisheries, and water resources also may be affected. Warmer temperatures, more severe droughts, storms and floods, and sea level rise could have a wide range of impacts. All these stresses can add to existing stresses on resources caused by other influences such as population growth, land-use changes, and pollution.

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Human-induced climate change has the potential to alter the prevalence and severity of extremes such as heat waves, cold waves, severe storms, floods and droughts. Though predicting changes in these types of events under a changing climate is difficult, understanding vulnerabilities to such changes is a critical part of estimating future climate change impacts on human health, society and the environment.

It is important to understand that directly linking any one specific extreme event (for example, a severe hurricane) to climate change is not possible. However, climate change and global warming may increase the probability of some ordinary weather events reaching extreme levels or of some extreme events becoming more extreme (U.S. Environmental Protection Agency [USEPA], 2006). It remains very difficult to assess the impact of global warming on extreme weather events, in large part because this analysis depends greatly on regional forecasts for global warming. Global warming will almost certainly have different effects on different regions of the Earth, so areas will not be equally susceptible to increased or more intense extreme weather events. Although regional climate forecasts are improving, they are still uncertain (Climate Institute, Date Unknown). These many uncertainties may exist regarding magnitude or severity; however, many sources indicate that future weather patterns and increased intensities are anticipated as a result of climate change, along with atmospheric, precipitation, storm and sea level changes (USEPA, 2007).

VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For severe storms, the entire County has been identified as the hazard area. Therefore, all assets in Saratoga County (population, structures, critical facilities and lifelines), as described in the County Profile section (Section 4), are vulnerable. The following text evaluates and estimates the potential impact of severe storms on the County including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact, including: (1) impact on life, safety and health of County residents, (2) general building stock, (3) critical facilities, (4) economy and (5) future growth and development
- Further data collections that will assist understanding of this hazard over time
- Overall vulnerability conclusion

Overview of Vulnerability

Severe storms include high winds and air speeds that result in power outages, disruptions to transportation corridors and equipment, loss of workplace access, significant property damage, injuries and loss of life, and the need to shelter and care for individuals impacted by the events. A large amount of damage can be inflicted by trees, branches, and other objects that fall onto power lines, buildings, roads, vehicles, and, in some cases, people. The risk assessment for severe storm evaluates available data for a range of storms included in this hazard category.

Due to the County's inland location, the loss associated with hurricanes is primarily associated with severe thunderstorm or tropical storm/hurricane-related severe winds and rain (see flooding discussion in Section 5.4.1 Flood). Secondary flooding associated with the torrential downpours during severe storms is also a primary concern in the County. The County has experienced flooding in association with numerous severe storms in the past.

In the study area, winds associated with a tropical/hurricane storm event are similar to a severe wind storm and therefore, can support analysis of the severe storm event for this study area. The entire inventory of the County is at risk of being damaged or lost due to impacts of severe wind. Certain areas, infrastructure, and types of building are at greater risk than others due to proximity to falling hazards and/or their manner of construction.

Potential losses associated with high wind events were calculated for the County for two probabilistic wind events, the 100-year and 500-year mean return period (MRP) wind events. The impacts on population, existing structures and critical facilities are presented below, following a summary of the data and methodology used.

Data and Methodology

After reviewing historic data, the HAZUS-MH methodology and model were used to analyze the wind (severe storm) hazard for Saratoga County. Data used to assess this hazard include data available in the HAZUS-MH MR3 hurricane model, NOAA NCDC data, professional knowledge, and information provided by the Planning Committee.

HAZUS-MH contains data on historic hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. Hurricane and inventory data available in HAZUS-MH were used to evaluate potential losses from the 100- and 500-year MRP events (severe wind impacts). Locally available inventory data were reviewed to determine their appropriateness for inclusion. Other than data for critical facilities, the default data in HAZUS-MH MR3 was the best available for use in this evaluation. The 11 residential and 10 commercial occupancy classes available in HAZUS-MH were condensed into the following occupancy classes (residential, commercial, industrial, agricultural, religious, government, and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single family dwellings. In addition, impacts to critical facilities were evaluated for the 100-year and 500-year MRP events.

Impact on Life, Health and Safety

The impact of severe storms on life, health and safety is dependent upon the severity of the storm event. Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. It is assumed that the entire County population is exposed to the severe storm hazard. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Table 5.4.3-7 summarizes the population over the age of 65 and individuals living below the Census poverty threshold. Additionally, residents living in mobile homes are particularly vulnerable to wind events due to the construction of their housing. The Impact on General Building Stock subsection below discusses mobile homes in the County further.

Table 5.4.3-7 Vulnerable Population Exposed to Severe Storm Events in Saratoga County

Population Category	Number of Persons Exposed	Percent of Total County Population
Elderly (Over 65 years of age) (1)	22,741	11.3
Persons living below Census poverty threshold* (2)	11,238	5.6
Elderly (Over 65 years of age) living below Census poverty threshold (2)	1,283	0.6

Source(s): (1) HAZUS-MH MR3, 2007; (2) U.S. Census 2000.
* The Census poverty threshold for a three person family unit is approximately $15,000.

For a 100-year MRP event, HAZUS-MH MR3 estimates that no households will be displaced and zero households will require temporary shelter. HAZUS-MH MR3 estimates 8 tons of brick and wood debris and a total of 18,267 tons of tree debris will be generated. For a 500-year MRP event, HAZUS-MH MR3 also estimates that no households will be displaced and zero households will require temporary shelter. HAZUS-MH MR3 estimates 2,605 tons of brick and wood debris and a total of 87,706 tons of tree debris will be generated. Table 5.4.3-8 estimates the debris produced for the 500-year MRP event.

Please note that the HAZUS-MH Hurricane Model Technical Manual and User Manual recommend that the estimated debris volume be treated as a low estimate. There may be other sources of vegetative and non-vegetative debris (i.e., flooding) not being modeled in HAZUS-MH in combination with the wind. Therefore, this is likely a conservative estimate and may be higher if multiple impacts occur.

Table 5.4.3-8 Debris Production for 500-Year MRP Event Winds

Jurisdiction	Brick and Wood (tons)	Concrete (tons)	Tree (tons)
Ballston (T)	97	0	3,432
Ballston Spa (V)	83	0	147
Charlton (T)	15	0	3,147
Clifton Park (T)	487	0	5,169
Corinth (T)	9	0	7,092
Corinth (V)	23	0	99
Day (T)	4	0	6,172
Edinburg (T)	2	0	5,756
Galway (T)	13	0	4,195
Galway (V)	0	0	24
Greenfield (T)	25	0	6,462
Hadley (T)	3	0	5,085
Halfmoon (T)	292	0	3,126
Malta (T)	192	0	2,829
Mechanicville (C)	135	0	103
Milton (T)	80	0	3,297
Moreau (T)	75	0	4,969
Northumberland (T)	53	0	3,105
Providence (T)	1	0	5,628
Round Lake (V)	4	0	132
Saratoga (T)	46	0	3,798
Saratoga Springs (C)	470	0	3,316
Schuylerville (V)	27	0	71
South Glens Falls (V)	56	0	130
Stillwater (T)	61	0	5,132
Stillwater (V)	29	0	35
Victory (V)	7	0	68
Waterford (T)	140	0	803
Waterford (V)	70	0	36
Wilton (T)	106	0	4,348
Saratoga County	**2,605**	**0**	**87,706**

Source: HAZUS-MH MR3, 2007

Impact on General Building Stock

After considering the population exposed to the severe storm hazard, the value of general building stock exposed to and damaged by 100- and 500-year MRP events was evaluated. Potential damage is the modeled loss that could occur to the exposed inventory. HAZUS-MH MR3 estimates there is a total building replacement value (structure only) of greater than $15 billion in Saratoga County. Greater than 75-percent of the building stock value is associated with residential housing. The analysis below uses the replacement value (building structure and does not include building contents) with the valuation of general building stock and the loss estimates determined in Saratoga County based on the default general building stock database provided in HAZUS-MH MR3. The general building stock valuations provided in HAZUS-MH MR3 are Replacement Cost Value from RSMeans as of 2006.

Table 5.4.3-9 presents the total exposure value for general building stock by occupancy class for the County.

Table 5.4.3-9 Building Stock Replacement Value (Structure Only) by Occupancy Class

Jurisdiction	Total RV	Residential RV	Commercial RV	Industrial RV
Town of Ballston	$601,197,000	$470,268,000	$75,877,000	$24,994,000
Village of Ballston Spa	$404,132,000	$291,028,000	$76,941,000	$12,181,000
Town of Charlton	$288,687,000	$262,633,000	$13,737,000	$4,483,000
Town of Clifton Park	$2,854,941,000	$2,244,626,000	$494,691,000	$51,450,000
Town of Corinth	$194,818,000	$178,632,000	$9,071,000	$3,735,000
Village of Corinth	$163,188,000	$105,939,000	$26,503,000	$10,246,000
Town of Day	$197,671,000	$175,445,000	$8,350,000	$6,932,000
Town of Edinburg	$227,918,000	$215,146,000	$5,613,000	$2,161,000
Town of Galway	$305,562,000	$280,210,000	$12,956,000	$3,693,000
Village of Galway	$15,143,000	$12,488,000	$970,000	$59,000
Town of Greenfield	$429,691,000	$366,426,000	$37,011,000	$11,013,000
Town of Hadley	$131,228,000	$120,658,000	$6,426,000	$1,423,000
Town of Halfmoon	$1,197,056,000	$936,865,000	$202,691,000	$35,037,000
Town of Malta	$919,251,000	$754,808,000	$116,478,000	$29,272,000
City of Mechanicville	$303,431,000	$245,357,000	$44,402,000	$4,279,000
Town of Milton	$723,953,000	$576,510,000	$79,869,000	$30,072,000
Town of Moreau	$612,651,000	$479,437,000	$96,135,000	$16,278,000
Town of Northumberland	$261,571,000	$234,673,000	$17,050,000	$4,646,000
Town of Providence	$117,847,000	$101,245,000	$6,863,000	$3,050,000
Village of Round Lake	$41,720,000	$29,647,000	$9,894,000	$711,000
Town of Saratoga	$248,564,000	$208,716,000	$21,992,000	$7,413,000
City of Saratoga Springs	$2,767,259,000	$1,772,811,000	$616,582,000	$70,037,000
Village of Schuylerville	$84,535,000	$58,664,000	$16,187,000	$2,322,000
Village of South Glens Falls	$202,667,000	$153,852,000	$37,731,000	$1,657,000
Town of Stillwater	$342,459,000	$282,521,000	$30,926,000	$18,421,000
Village of Stillwater	$92,853,000	$77,736,000	$7,190,000	$1,948,000
Village of Victory	$30,241,000	$25,170,000	$1,705,000	$503,000
Town of Waterford	$470,581,000	$373,895,000	$33,769,000	$53,946,000
Village of Waterford	$135,005,000	$106,421,000	$15,714,000	$1,286,000
Town of Wilton	$793,866,000	$609,341,000	$143,919,000	$13,130,000

Jurisdiction	Total RV	Residential RV	Commercial RV	Industrial RV
Saratoga County	**$15,159,686,000**	**$11,751,168,000**	**$2,267,243,000**	**$426,378,000**

Source: HAZUS-MH MR3, 2007

Notes:

(1) Replacement value (RV) reflects the building structure and does not include building contents. The valuation of general building stock and the loss estimates determined in Saratoga County were based on the default general building stock database provided in HAZUS-MH MR3. The general building stock valuations provided in HAZUS-MH MR3 are Replacement Cost Value from RSMeans as of 2006.

(2) Total RV is the sum of all building classes (Residential, Commercial, Industrial, Agricultural, Religious, Government and Education).

(3) The total RV for the agricultural occupancy class is $57,143,000; the total RV for the religious occupancy class is $173,400,000; the total RV for the government occupancy class is $147,829,000; and the total RV for the education occupancy class is $336,525,000.

The HAZUS-MH hurricane analysis considers damage associated with significant winds. Such wind impacts also could occur as a result of the severe wind storms or tornadoes and therefore, are considered relevant to the severe storm hazard. Rain often is associated with severe storms and heavy rains could result in flooding. Flooding is addressed under the flood hazard (Section 5.4.1).

The entire study area is considered at risk for the severe storm wind hazard. Expected building damage was evaluated by HAZUS-MH across the following damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 5.4.3-10 summarizes the definition of the damage categories.

Table 5.4.3-10 Description of Damage Categories

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
1. No Damage or Very Minor Damage Little or no visible damage from the outside. No broken windows, or failed roof deck. Minimal loss of roof over, with no or very Limited water penetration.	≤2%	No	No	No	No	No
2. Minor Damage Maximum of one broken window, door or garage door. Moderate roof cover loss that can be Covered to prevent additional water Entering the building. Marks or dents on walls requiring painting or patching for repair.	>2% and ≤15%	One window, door, or garage door failure	No	<5 impacts	No	No
3. Moderate Damage Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.	>15% and ≤50%	> one and ≤ the larger of 20% & 3	1 to 3 panels	Typically 5 to 10 impacts	No	No
4. Severe Damage Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	>50%	> the larger of 20% & 3 and ≤50%	>3 and ≤25%	Typically 10 to 20 impacts	No	No
5. Destruction Complete roof failure and/or, failure of wall frame. Loss of more than 50% of roof sheathing.	Typically >50%	>50%	>25%	Typically >20 impacts	Yes	Yes

Source: HAZUS-MH Hurricane Technical Manual

According to HAZUS-MH MR3 estimates, no buildings will be completely destroyed as a result of the 100- and 500-year events and less than one-percent will be severely damaged. Residential buildings comprise the majority of the building inventory and are estimated to experience the majority of building damage (no damage to moderate damage). Wind speeds associated with a 100-year event, as described earlier in this profile, equate to a tropical storm; wind speeds associated with a 500-year event equate to a Category 1 hurricane.

Table 5.4.3-11 summarizes the general building stock damage estimated for the 100- and 500-year MRP hurricane events for the County as a whole. Table 5.4.3-12 summarizes the general building stock damage estimated for the 100- and 500-year MRP hurricane events for each participating jurisdiction. The data shown in both tables indicate total losses associated with wind damage to building structure only. The damage estimates include buildings damaged at all severity levels from minor damage to total destruction and the total dollar damage reflects the overall impact to buildings at an aggregate level.

Table 5.4.3-11. Estimated Saratoga County Building Replacement Value (Structure Only) Damaged by the 100-Year and 500-Year MRP Winds

Occupancy Category	Building Value Damage (Structure Only)	
	100-Year	500-Year
Residential	$1,122,456	$21,624,578
Commercial	$4,948	$487,685
Industrial	$5,523	$110,925
Agricultural, Religious Government , Education	$1,996	$137,527

Source: HAZUS-MH MR3, 2007

Table 5.4.3-12. Estimated Building Value (Structure Only) Damaged by the 100-Year and 500-Year MRP Winds

Jurisdiction	Total (All Occupancy Classes)		Percentage of Total Building Value		Residential Buildings		Commercial Buildings		Industrial Buildings	
	100 Yr	500 Yr	100 Yr	500 Yr	100 Yr	500 Yr	100 Yr	500 Yr	100 Yr	500 Yr
Town of Ballston	$42,712	$992,843	0.01	0.2	$42,712	$962,448	$0	$16,663	$0	$7,563
Village of Ballston Spa	$15,672	$453,031	0.00	0.1	$15,672	$429,755	$0	$15,071	$0	$3,409
Town of Charlton	$34	$392,830	0.00	0.1	$34	$387,692	$0	$2,689	$0	$1,149
Town of Clifton Park	$353,616	$4,805,764	0.01	0.2	$353,616	$4,643,435	$0	$130,307	$0	$16,941
Town of Corinth	$1,746	$227,622	0.00	0.1	$1,746	$225,915	$0	$907	$0	$462
Village of Corinth	$243	$162,906	0.00	0.1	$243	$151,556	$0	$5,247	$0	$2,049
Town of Day	$0	$166,168	0.00	0.1	$0	$163,471	$0	$835	$0	$1,187
Town of Edinburg	$0	$203,662	0.00	0.1	$0	$202,373	$0	$561	$0	$228
Town of Galway	$308	$333,248	0.00	0.1	$308	$330,514	$0	$1,296	$0	$569
Village of Galway	$16	$15,027	0.00	0.1	$16	$14,761	$0	$97	$0	$6
Town of Greenfield	$2,377	$492,394	0.00	0.1	$2,377	$485,598	$0	$3,701	$0	$1,571
Town of Hadley	$531	$130,471	0.00	0.1	$531	$129,398	$0	$643	$0	$158
Town of Halfmoon	$193,647	$2,075,541	0.02	0.2	$193,647	$2,007,663	$0	$53,178	$0	$9,475
Town of Malta	$73,809	$1,603,517	0.01	0.2	$73,809	$1,564,927	$0	$27,387	$0	$7,164
City of Mechanicville	$34,488	$448,179	0.01	0.1	$34,488	$433,502	$0	$11,337	$0	$946
Town of Milton	$5,624	$1,039,415	0.00	0.1	$5,624	$1,021,489	$0	$9,788	$0	$4,388
Town of Moreau	$2,866	$916,181	0.00	0.1	$2,866	$896,537	$0	$14,800	$0	$2,764
Town of Northumberland	$24,001	$542,701	0.01	0.2	$24,001	$536,393	$0	$4,142	$0	$1,034
Town of Providence	$794	$99,543	0.00	0.1	$794	$97,802	$0	$686	$0	$386
Village of Round Lake	$2,245	$52,384	0.01	0.1	$2,245	$49,969	$0	$1,979	$0	$142
Town of Saratoga	$41,353	$492,360	0.02	0.2	$41,353	$482,530	$0	$5,408	$0	$2,247
City of Saratoga Springs	$82,964	$3,179,557	0.00	0.1	$82,964	$2,979,913	$0	$120,752	$0	$16,966
Village of Schuylerville	$8,734	$122,160	0.01	0.1	$8,734	$115,516	$0	$4,291	$0	$636
Village of South Glens Falls	$27	$297,631	0.00	0.1	$27	$288,100	$0	$7,307	$0	$338
Town of Stillwater	$56,356	$652,229	0.02	0.2	$56,356	$636,330	$0	$7,703	$0	$5,865
Village of Stillwater	$18,607	$188,454	0.02	0.2	$18,607	$184,937	$0	$1,622	$0	$401
Village of Victory	$4,698	$59,631	0.02	0.2	$4,698	$58,527	$0	$410	$0	$121
Town of Waterford	$132,536	$851,050	0.03	0.2	$122,917	$820,937	$3,377	$8,559	$5,395	$19,262
Village of Waterford	$30,672	$219,615	0.02	0.2	$27,825	$212,239	$1,571	$4,171	$129	$332

Jurisdiction	Total (All Occupancy Classes)		Percentage of Total Building Value		Residential Buildings		Commercial Buildings		Industrial Buildings	
	100 Yr	500 Yr	100 Yr	500 Yr	100 Yr	500 Yr	100 Yr	500 Yr	100 Yr	500 Yr
Town of Wilton	$4,247	$1,144,605	0.00	0.1	$4,247	$1,110,356	$0	$26,149	$0	$3,166
Saratoga County	**$1,134,923**	**$22,360,715**	**0.01**	**0.1**	**$1,122,456**	**$21,624,578**	**$4,948**	**$487,685**	**$5,523**	**$110,925**

Source: HAZUS-MH MR3, 2007

Notes:

(1) Values represent replacement values (RV) for building structure only (does not include contents).

(2) The valuation of general building stock and the loss estimates determined in Saratoga County were based on the default general building stock database provided in HAZUS-MH MR3. The general building stock valuations provided in HAZUS-MH MR3 are Replacement Cost Value from RSMeans as of 2006.

Residential buildings account for a majority of the building stock damage and also comprise the majority of the building inventory. Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Figures 5.4.3-18 and 5.4.3-19 show the density of damage estimated for residential structures for the 100-year MRP event and 500-year MRP events.

Mobile homes are particularly vulnerable to severe storms. According to Saratoga County, there are 128 mobile home parks throughout the County. HAZUS-MH estimates there are 9,940 manufactured homes in Saratoga County with a total structural replacement value of approximately $345 million or approximately $35,000 for each home. HAZUS-MH MR3 estimates greater than $57,000 in building damages to manufactured housing as a result of a 100-year event. For a 500-year event, HAZUS-MH MR3 estimates approximately $1 million in manufactured housing building damages.

Impact on Critical Facilities

100-Year MRP Event – HAZUS-MH MR3 estimates the police departments, fire stations and schools will not suffer damage during a 100-year event. All facilities are estimated to be fully functional (no loss of use).

500-Year MRP Event – HAZUS-MH estimates the police departments, fire stations and schools have less than one-percent chance of suffering minor damage during a 500-year event. All facilities are estimated to be fully functional (no loss of use).

Impact on Economy

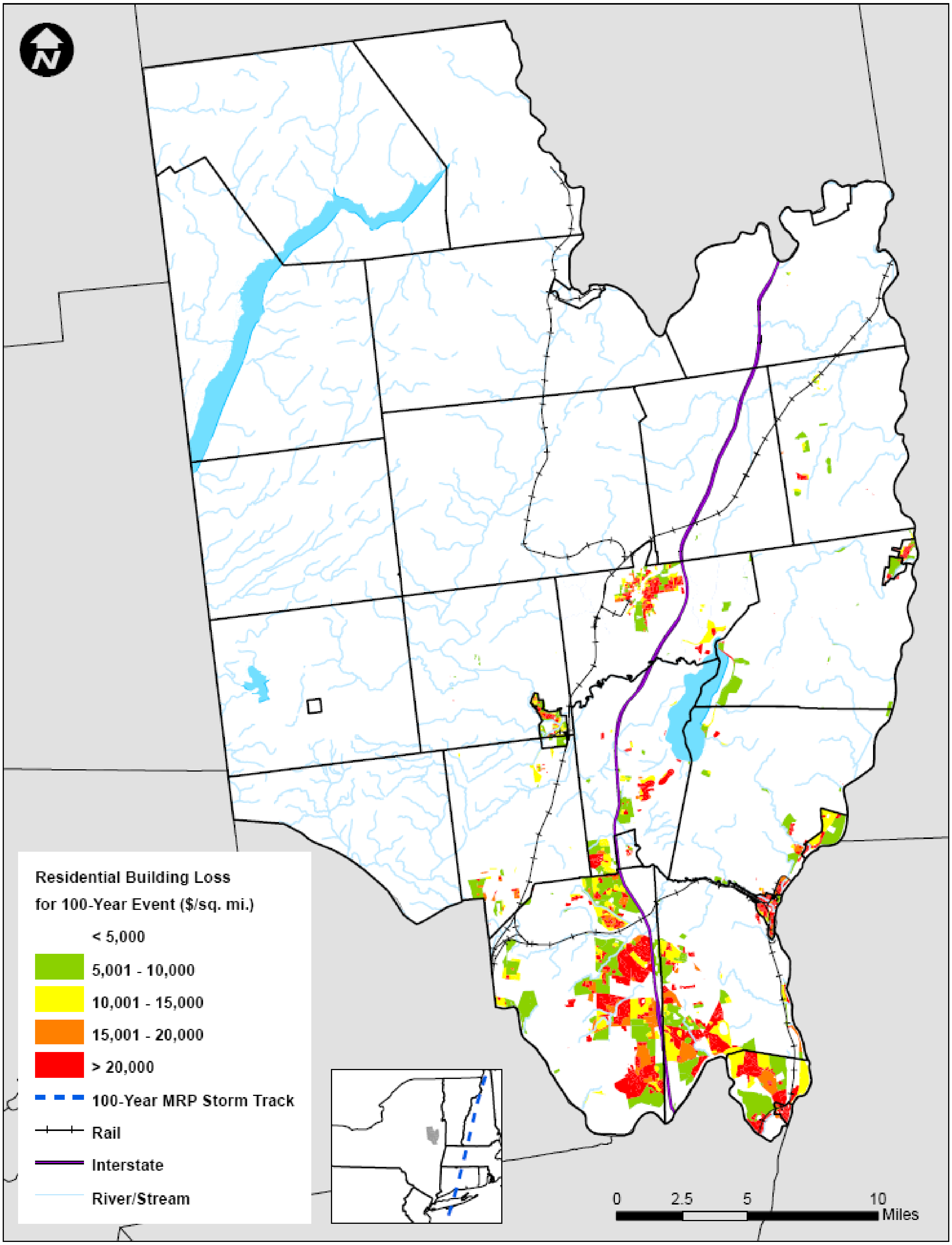
Severe storms also have impacts on the economy, including: loss of business function, damage to inventory, relocation costs, wage loss and rental loss due to the repair/replacement of buildings. HAZUS-MH estimates the total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the Impact on General Building Stock sub-section discussed earlier. Business interruption losses are the losses associated with the inability to operate a business because of the damage sustained during the storm.

HAZUS-MH MR3 does not estimate that any commercial or industrial business interruption loss will occur for the 100-year MRP event. For the 500-year MRP event, HAZUS-MH estimates a loss of approximately $1 million for the County as a whole; associated with relocation and rental costs for residential, commercial and industrial occupancy classes.

Transportation lifelines are not considered particularly vulnerable to the 100- and 500-year MRP severe storm wind hazard. However, utility structures could suffer damage associated with falling tree limbs or other debris. Such impacts can result in the loss of power, which can impact business operations and can impact heating or cooling provision to citizens (including the young and elderly, who are particularly vulnerable to temperature-related health impacts).

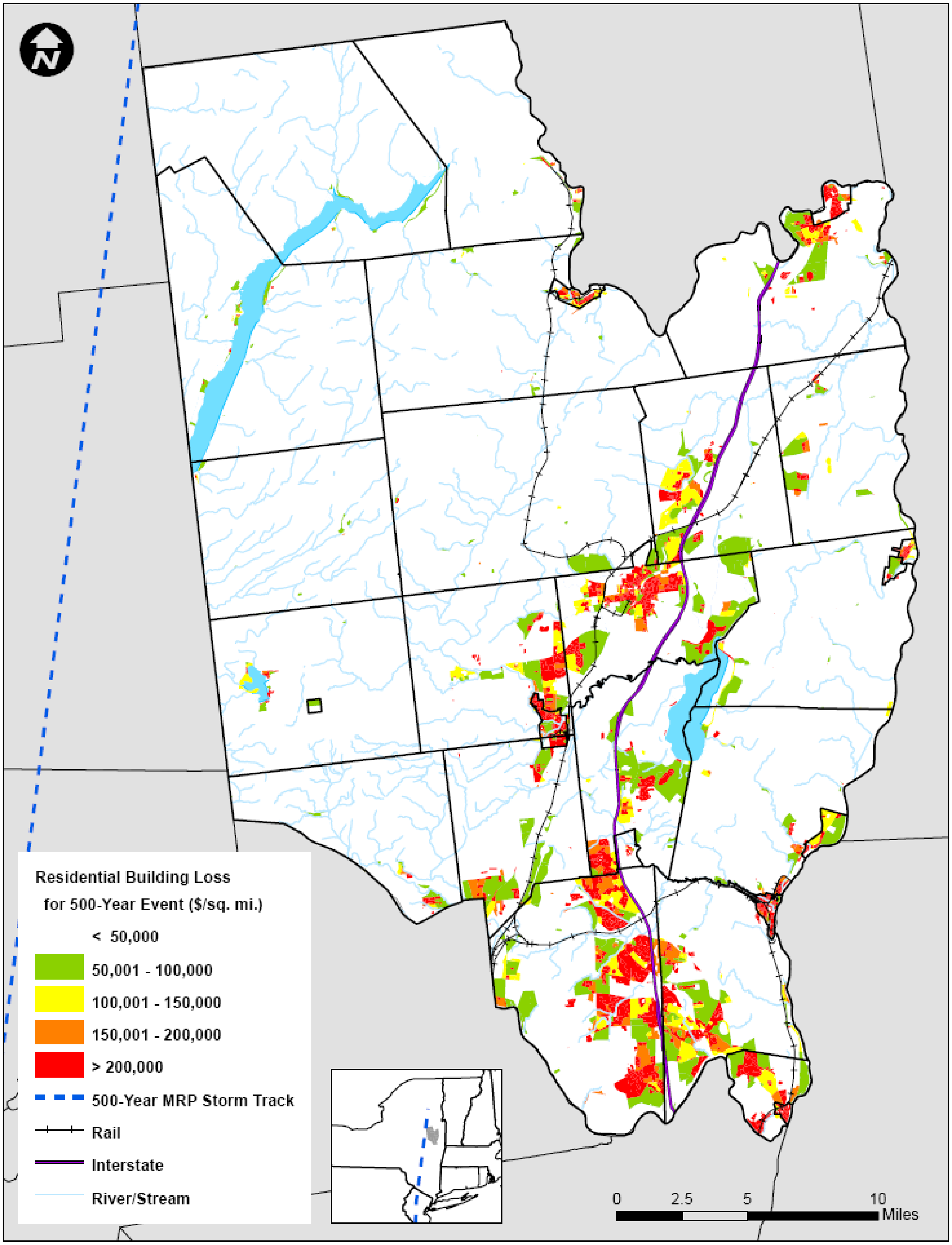
It is estimated that the impact to the economy, as a result of a severe storm event, would be considered “medium” in accordance with the risk ranking shown in Table 5.3-4 in Section 5.3.

Figure 5.4.3-18. Density of Losses for Residential Structures (Structure Only) for the 100-Year MRP Wind Event



Source: HAZUS-MH MR3, 2007

Figure 5.4.3-19. Density of Losses for Residential Structures (Structure Only) for the 500-Year MRP Wind Event



Source: HAZUS-MH MR3, 2007

Future Growth and Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the County. Any areas of growth could be potentially impacted by the severe storm hazard because the entire planning area is exposed and vulnerable. For the severe storm hazard, the entire County has been identified as the hazard area. Please refer to Section 4 (County Profile) and each jurisdictions' annex (Section 9) for hazard maps that illustrate where potential new development is located in relation to Saratoga County's hazard areas.

Additional Data and Next Steps

Over time, Saratoga County will obtain additional data to support the analysis of this hazard. Data that will support the analysis would include additional detail on past hazard events and impacts, additional information on estimated frequency of these events, and future data regarding events and damages as they occur. In addition, information on particular buildings or infrastructure and their value will support updates regarding the particular assets in the County that are most vulnerable to severe storm (wind-related) events. Additional utility data would support an improved assessment of potential damage for this infrastructure category.

For the severe storm events that cannot currently be directly modeled in HAZUS-MH (tornado, thunderstorm, etc.), additional detailed loss data from past and future events will assist in assessing potential future losses. Based on these values and a sufficient number of data points, future losses could be modeled. Alternately, percent of damage estimates could be made and multiplied by the inventory value to estimate potential losses. This methodology is based on FEMA's How To Series (FEMA 386-2), Understanding Your Risks, Identifying and Estimating Losses (FEMA, 2001) and FEMA's Using HAZUS-MH for Risk Assessment (FEMA 433) (FEMA, 2004). Finally, with time, HAZUS-MH will be released with modules that address hurricane wind and associated flooding as one model and will include a tornado module. As this version of HAZUS-MH is released, the County can run analyses for the tornado hazard and re-run an analysis for an overall picture of the hurricane-associated wind and flood damages.

Overall Vulnerability Assessment

Severe storms are common in the study area, often causing impacts and losses to the structures, facilities, utilities, and population in Saratoga County. Existing and future mitigation efforts should continue to be developed and employed that will enable the study area to be prepared for these events when they occur. The overall hazard ranking determined by the Planning Committee for this hazard is "High" with a "frequent" probability of occurrence (see Tables 5.3-3 through 5.3-6 in Section 5.3).